

Statistical Methods – COSC 6323 - HomeWork-7

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INTRODUCTION

11 Subjects(Participants) drove around 19 km in Texas Town measuring their stress and driving variable data. The variables used here are speed, accelerator, brake and steering angle. And to measure the stress, perinasal perspiration value is taken and considered.

This report purely concentrates on:

- i) Possibility of multi-collinearity
- ii) Extracting meaningful data through forward, backward and mixed selection approach.
- iii) Visualizations to support the analysis.

GETTING STARTED WITH THE HOMEWORK

I first wrote the steps for 1 subject and repeated the same for other 11 subjects as well.

Step-1 Installing required packages and libraries.

Step-2 Reading the csv files and dropping the NA values. Also, assigned a subject ID to each subject to treat (1|SubjectID as random effect).

```
s1 <- read.csv("C:/Users/ndine/OneDrive/Desktop/Data-HW7/S01.csv")
s1_b <- read.csv("C:/Users/ndine/OneDrive/Desktop/Data-HW7/S01-Baseline.csv")
s1 <- s1 %>% drop_na(pp_nr5, Accelerator, Brake, Steering, Speed)
s1$SubjectID <- 1
```

Step-3 Manipulating data to find PPNATDi. Calculated mean of pp_nr2 value and subtracted it from pp_nr5. For checking whether normalized pp values are better, calculated mean of log pp_nr2 values and subtracted it from pp_nr5

```
mean_pp2 <- mean(s1_b$pp_nr2)
s1$new_pp <- s1$pp_nr5 - mean_pp2

log_mean_pp2 <- mean(log(s1_b$pp_nr2))
s1$log_new_pp <- log(s1$pp_nr5) - log_mean_pp2
```

Step-4 Finding mean and sd for all the variables (accelerator, speed, brake and steering). As question mentioned, we need to compute 30 seconds into the past [t-30,t] for predictors and 5 seconds into the future (t,t+5) for response variable. And also calculated mean and sd for the terms.

```
#mean and sd for speed
s1$mean_speed <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$mean_speed[x] <- mean(s1$Speed[a:x])
  a <- a +1
}
s1$sd_speed <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$sd_speed[x] <- sd(s1$Speed[a:x])
  a <- a +1
}
```

```

#mean and sd for accelerator
s1$mean_acc <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$mean_acc[x] <- mean(s1$Accelerator[a:x])
  a <- a +1
}
s1$sd_acc <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$sd_acc[x] <- sd(s1$Accelerator[a:x])
  a <- a +1
}

#mean and sd for brake
s1$mean_brake <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$mean_brake[x] <- mean(s1$Brake[a:x])
  a <- a +1
}
s1$sd_brake <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$sd_brake[x] <- sd(s1$Brake[a:x])
  a <- a +1
}

#mean and sd for steering
s1$mean_steering <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$mean_steering[x] <- mean(s1$Steering[a:x])
  a <- a +1
}
s1$sd_steering <- 0
a <- 1
for(x in 30:nrow(s1)) {
  s1$sd_steering[x] <- sd(s1$Steering[a:x])
  a <- a +1
}

s1$delta_pp <- 0
a <- 2
b <- 6
c <- (nrow(s1)-5)
for (x in 1:c) {

  s1$delta_pp[x] <- mean(s1$new_pp[a:b])
  s1$log_delta_pp[x] <- mean(s1$log_new_pp[a:b])
  a <- a+1
}

```

```
b <- b+1
}
```

Step-5 Removing first 29 and last 5 values as they are 0. These just create noise in the model. So, decided to remove them.

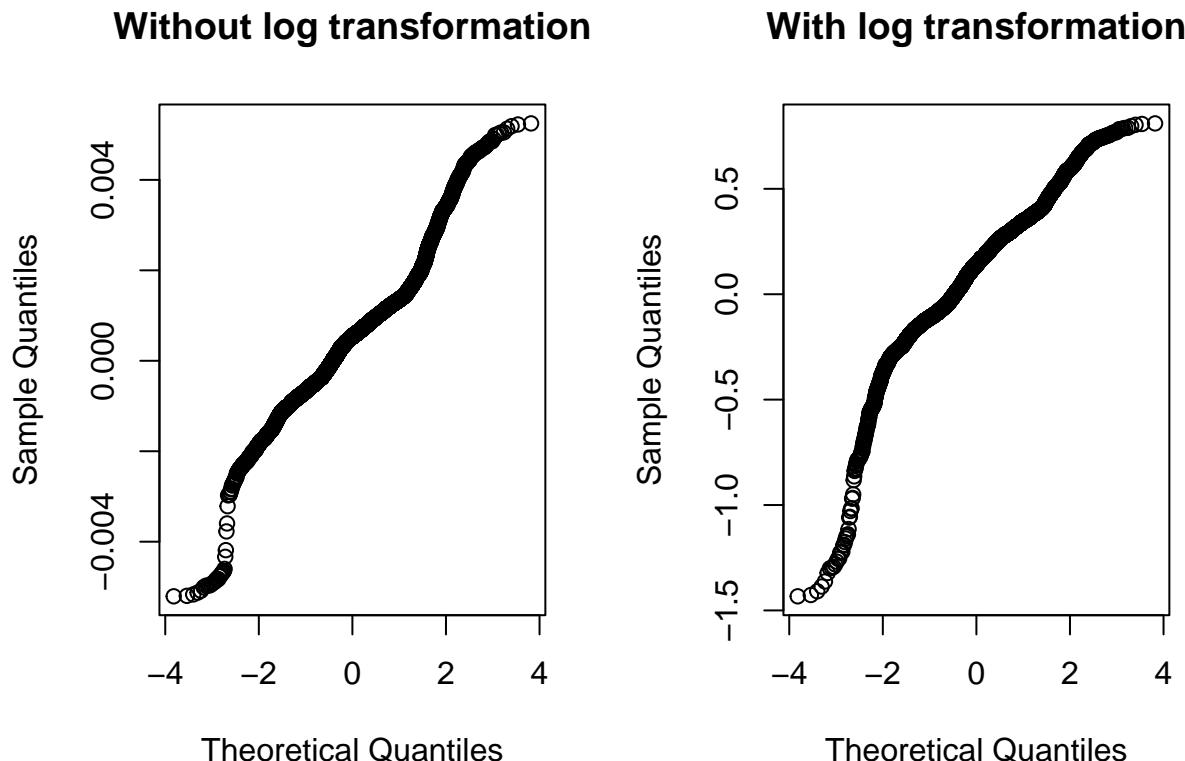
```
s1 <- s1[-c(1:29),]
s1 <- head(s1, -5)
```

Step-6 Merging all the data-sets into 1 using bind_rows. We can differentiate the dataframes with the subjectID column.

```
final <- bind_rows(s1,s2,s3,s4,s5,s6,s7,s8,s10,s11,s12)
```

Step-7 Finding normality to finalize the response variable.

```
par(mfrow=c(1,2))
qqnorm(final$delta_pp, main = "Without log transformation")
qqnorm(final$log_delta_pp, main = "With log transformation")
```



Step-8 Finding the summary of multi regression model.

```
model <- lm(log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc +
               mean_brake + sd_brake + mean_steering + sd_steering + (1|SubjectID) , data = final)
summary(model)
```

```
##
## Call:
## lm(formula = log_delta_pp ~ mean_speed + sd_speed + mean_acc +
##     sd_acc + mean_brake + sd_brake + mean_steering + sd_steering +
```

```

##      (1 | SubjectID), data = final)
##
## Residuals:
##       Min     1Q   Median     3Q    Max
## -1.44715 -0.16614  0.02594  0.15892  0.66336
##
## Coefficients: (1 not defined because of singularities)
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.1040811  0.0267821 -3.886 0.000103 ***
## mean_speed   0.0019091  0.0001502 12.711 < 2e-16 ***
## sd_speed    -0.0016990  0.0004353 -3.903 9.57e-05 ***
## mean_acc     0.0040660  0.0008446  4.814 1.51e-06 ***
## sd_acc      -0.0041436  0.0012710 -3.260 0.001119 **
## mean_brake   -0.0002119  0.0004146 -0.511 0.609351
## sd_brake     0.0063825  0.0006690  9.540 < 2e-16 ***
## mean_steering -0.0001942  0.0003777 -0.514 0.607142
## sd_steering  -0.0018343  0.0002165 -8.471 < 2e-16 ***
## 1 | SubjectIDTRUE      NA       NA       NA       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2413 on 7450 degrees of freedom
## (4874 observations deleted due to missingness)
## Multiple R-squared:  0.0783, Adjusted R-squared:  0.07731
## F-statistic: 79.11 on 8 and 7450 DF,  p-value: < 2.2e-16

```

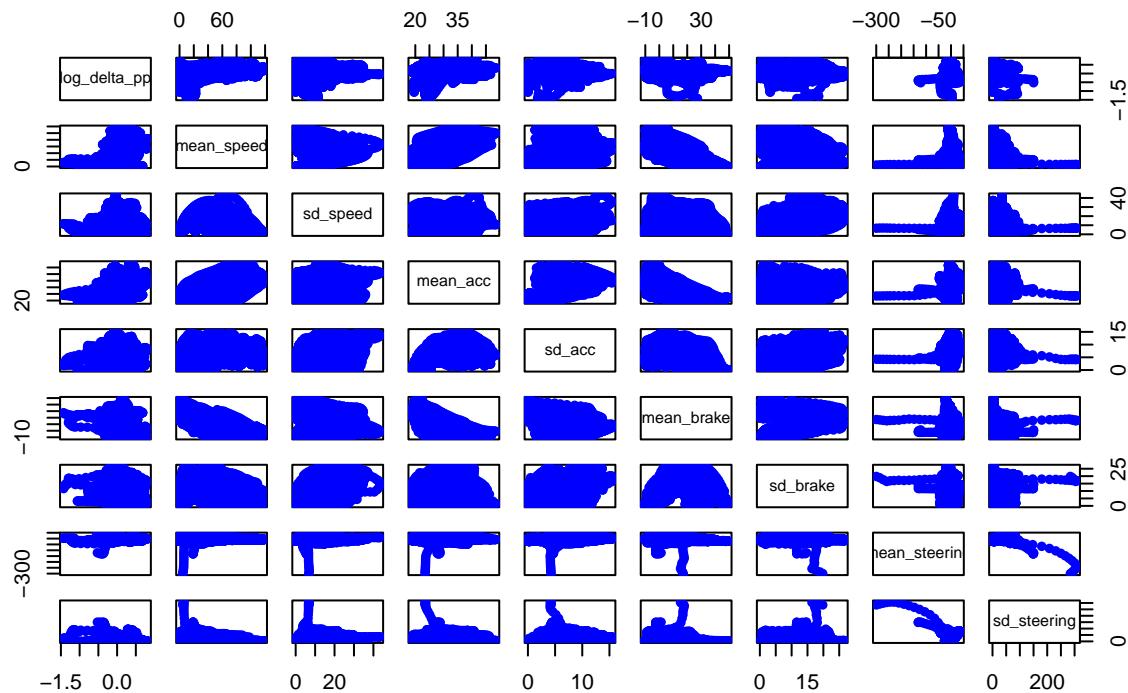
Step-9 Plotting matrix scatter plot.

```

input <- final[,c("log_delta_pp", "mean_speed", "sd_speed", "mean_acc", "sd_acc",
               "mean_brake", "sd_brake", "mean_steering", "sd_steering")]
plot(input, pch=16, col="blue",
      main="Matrix Scatterplot")

```

Matrix Scatterplot



Step-10 Checking multi collinearity using VIF value

```
vif<- ols_vif_tol(model)
max(vif$VIF)
```

```
## [1] 3.769341
```

Step-11 Step-wise Forward Regression

```
ols_step_forward_aic(model, details = TRUE)
```

```
## Forward Selection Method
## -----
## 
## Candidate Terms:
## 
## 1 . mean_speed
## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . mean_brake
## 6 . sd_brake
## 7 . mean_steering
## 8 . sd_steering
## 9 . 1 | SubjectID
## 
## Step 0: AIC = 562.0742
## log_delta_pp ~ 1
##
```

```

## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_speed 1 97.352 28.547 442.105 0.061 0.061
## mean_brake 1 295.829 16.625 454.027 0.035 0.035
## mean_acc 1 357.545 12.853 457.799 0.027 0.027
## sd_steering 1 499.099 4.082 466.570 0.009 0.009
## sd_acc 1 500.467 3.996 466.655 0.008 0.008
## mean_steering 1 514.957 3.089 467.563 0.007 0.006
## sd_speed 1 547.892 1.020 469.632 0.002 0.002
## sd_brake 1 562.248 0.115 470.537 0.000 0.000
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## 
## - mean_speed
## 
## 
## Step 1 : AIC = 97.35157
## log_delta_pp ~ mean_speed
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_brake 1 55.578 2.587 439.518 0.066 0.066
## sd_steering 1 63.127 2.142 439.963 0.065 0.065
## sd_acc 1 93.977 0.318 441.786 0.061 0.061
## sd_speed 1 96.298 0.181 441.924 0.061 0.061
## mean_steering 1 97.109 0.133 441.972 0.061 0.061
## mean_acc 1 97.782 0.093 442.012 0.061 0.061
## mean_brake 1 99.311 0.002 442.102 0.061 0.060
## 1 | SubjectID 1 564.074 -28.547 470.652 0.000 0.000
## -----
## 
## - sd_brake
## 
## 
## Step 2 : AIC = 55.57804
## log_delta_pp ~ mean_speed + sd_brake
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_steering 1 0.117 3.373 436.145 0.073 0.073
## sd_speed 1 48.784 0.518 439.000 0.067 0.067
## mean_acc 1 53.760 0.225 439.293 0.067 0.066
## sd_acc 1 55.743 0.108 439.410 0.066 0.066
## mean_steering 1 56.541 0.061 439.457 0.066 0.066
## mean_brake 1 57.278 0.018 439.500 0.066 0.066
## 1 | SubjectID 1 564.074 -31.134 470.652 0.000 0.000
## -----
## 
## - sd_steering
## 

```

```

## 
## Step 3 : AIC = 0.1168103
## log_delta_pp ~ mean_speed + sd_brake + sd_steering
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_acc 1 -10.577 0.742 435.403 0.075 0.074
## sd_speed 1 -7.891 0.585 435.560 0.075 0.074
## mean_brake 1 -2.931 0.295 435.850 0.074 0.073
## sd_acc 1 1.519 0.035 436.110 0.073 0.073
## mean_steering 1 2.056 0.004 436.141 0.073 0.073
## 1 | SubjectID 1 564.074 -34.507 470.652 0.000 0.000
## -----
## 
## - mean_acc
## 
## 
## Step 4 : AIC = -10.57713
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_speed 1 -25.250 0.972 434.431 0.077 0.076
## sd_acc 1 -18.706 0.591 434.812 0.076 0.076
## mean_steering 1 -9.286 0.041 435.362 0.075 0.074
## mean_brake 1 -8.821 0.014 435.389 0.075 0.074
## 1 | SubjectID 1 564.074 -35.248 470.652 0.000 0.000
## -----
## 
## - sd_speed
## 
## 
## Step 5 : AIC = -25.24999
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_acc 1 -33.597 0.602 433.829 0.078 0.077
## mean_steering 1 -23.432 0.011 434.421 0.077 0.076
## mean_brake 1 -23.266 0.001 434.430 0.077 0.076
## 1 | SubjectID 1 564.074 -36.221 470.652 0.000 0.000
## -----
## 
## - sd_acc
## 
## 
## Step 6 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed + sd_acc
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq

```

```

## -----
## mean_brake      1   -31.806    0.012   433.817    0.078    0.077
## mean_steering   1   -31.810    0.012   433.817    0.078    0.077
## 1 | SubjectID   1   564.074   -36.823   470.652    0.000    0.000
## -----
## 
## 
## No more variables to be added.
## 
## Variables Entered:
## 
## - mean_speed
## - sd_brake
## - sd_steering
## - mean_acc
## - sd_speed
## - sd_acc
## 
## 
## Final Model Output
## -----
## 
##                               Model Summary
## -----
## R                      0.280      RMSE          0.241
## R-Squared               0.078      Coef. Var     203.625
## Adj. R-Squared          0.077      MSE           0.058
## Pred R-Squared          0.076      MAE           0.189
## 
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
## 
##                               ANOVA
## -----
##                               Sum of
##                               Squares       DF   Mean Square      F      Sig.
## -----
## Regression            36.823        6      6.137    105.419    0.0000
## Residual              433.829    7452      0.058
## Total                 470.652    7458
## 
## 
##                               Parameter Estimates
## -----
##      model      Beta   Std. Error   Std. Beta      t      Sig      lower      upper
## -----
## (Intercept) -0.110      0.020          -5.592    0.000    -0.148    -0.071
## mean_speed   0.002      0.000       0.234    15.467    0.000     0.002     0.002
## sd_brake     0.006      0.001       0.176     9.520    0.000     0.005     0.008
## sd_steering  -0.002     0.000      -0.100    -8.560    0.000    -0.002    -0.001
## mean_acc     0.004      0.001       0.096     5.438    0.000     0.003     0.006
## sd_speed     -0.002     0.000      -0.062    -4.110    0.000    -0.003    -0.001
## sd_acc      -0.004     0.001      -0.052    -3.216    0.001    -0.006    -0.002

```

```

## -----
## Selection Summary
## -----
##   Variable      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
##   mean_speed    97.352   28.547   442.105   0.06065   0.06053
##   sd_brake     55.578   31.134   439.518   0.06615   0.06590
##   sd_steering   0.117   34.507   436.145   0.07332   0.07294
##   mean_acc     -10.577  35.248   435.403   0.07489   0.07440
##   sd_speed     -25.250  36.221   434.431   0.07696   0.07634
##   sd_acc       -33.597  36.823   433.829   0.07824   0.07750
## -----

```

Step-12 Step-wise Backward Regression

```
ols_step_backward_aic(model, details = TRUE)
```

```

## Backward Elimination Method
## -----
## Candidate Terms:
## 
## 1 . mean_speed
## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . mean_brake
## 6 . sd_brake
## 7 . mean_steering
## 8 . sd_steering
## 9 . 1 | SubjectID
## 
## Step 0: AIC = -28.07117
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + mean_brake + sd_brake + mean_steering + :
## 
## -----
##   Variable      DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
##   1 | SubjectID  1    -30.071   -36.850   433.801   0.078      0.077
##   mean_speed    1    564.074    0.000   470.652   0.000      0.000
##   sd_speed     1    564.074    0.000   470.652   0.000      0.000
##   mean_acc     1    564.074    0.000   470.652   0.000      0.000
##   sd_acc       1    564.074    0.000   470.652   0.000      0.000
##   mean_brake   1    564.074    0.000   470.652   0.000      0.000
##   sd_brake     1    564.074    0.000   470.652   0.000      0.000
##   mean_steering 1    564.074    0.000   470.652   0.000      0.000
##   sd_steering   1    564.074    0.000   470.652   0.000      0.000
## -----
## 
## 
## Variables Removed:
## 
## - 1 | SubjectID
## 
```

```

##
## Step 1 : AIC = -30.07117
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + mean_brake + sd_brake + mean_steering +
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_brake 1 -31.810 0.015 433.817 0.078 0.077
## mean_steering 1 -31.806 0.015 433.817 0.078 0.077
## sd_acc 1 -21.438 0.619 434.420 0.077 0.076
## sd_speed 1 -16.832 0.887 434.689 0.076 0.076
## mean_acc 1 -8.901 1.350 435.151 0.075 0.075
## sd_steering 1 39.427 4.178 437.980 0.069 0.069
## sd_brake 1 58.491 5.299 439.100 0.067 0.066
## mean_speed 1 127.958 9.408 443.209 0.058 0.057
## -----
## -
## - mean_brake
##
## -----
## Step 2 : AIC = -31.80972
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + sd_brake + mean_steering + sd_steering
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_steering 1 -33.597 0.012 433.829 0.078 0.077
## sd_acc 1 -23.432 0.604 434.421 0.077 0.076
## sd_speed 1 -17.479 0.951 434.767 0.076 0.076
## mean_acc 1 -4.104 1.731 435.548 0.075 0.074
## sd_steering 1 38.007 4.197 438.014 0.069 0.069
## sd_brake 1 56.560 5.288 439.104 0.067 0.066
## mean_speed 1 198.951 13.751 447.567 0.049 0.048
## -----
## -
## - mean_steering
##
## -----
## Step 3 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + sd_brake + sd_steering
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_acc 1 -25.250 0.602 434.431 0.077 0.076
## sd_speed 1 -18.706 0.983 434.812 0.076 0.076
## mean_acc 1 -6.060 1.721 435.550 0.075 0.074
## sd_steering 1 37.393 4.266 438.095 0.069 0.069
## sd_brake 1 54.570 5.276 439.105 0.067 0.066
## mean_speed 1 200.081 13.926 447.755 0.049 0.048
## -----
## -
## -
## No more variables to be removed.

```

```

##
## Variables Removed:
##
## - 1 | SubjectID
## - mean_brake
## - mean_steering
##
##
## Final Model Output
## -----
##
## Model Summary
## -----
## R           0.280      RMSE        0.241
## R-Squared   0.078      Coef. Var  203.625
## Adj. R-Squared 0.077      MSE         0.058
## Pred R-Squared 0.076      MAE         0.189
##
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
## ANOVA
## -----
##          Sum of
##          Squares    DF   Mean Square     F     Sig.
## -----
## Regression  36.823     6       6.137  105.419  0.0000
## Residual    433.829   7452      0.058
## Total        470.652   7458
##
## Parameter Estimates
## -----
##    model   Beta  Std. Error  Std. Beta    t    Sig   lower  upper
## -----
## (Intercept) -0.110    0.020          -5.592  0.000  -0.148  -0.071
## mean_speed   0.002    0.000     0.234  15.467  0.000   0.002  0.002
## sd_speed    -0.002    0.000    -0.062  -4.110  0.000  -0.003  -0.001
## mean_acc    0.004    0.001     0.096  5.438  0.000   0.003  0.006
## sd_acc     -0.004    0.001    -0.052  -3.216  0.001  -0.006  -0.002
## sd_brake    0.006    0.001     0.176  9.520  0.000   0.005  0.008
## sd_steering -0.002    0.000    -0.100  -8.560  0.000  -0.002  -0.001
##
## Backward Elimination Summary
## -----
##    Variable    AIC     RSS   Sum Sq   R-Sq   Adj. R-Sq
## -----
## Full Model -28.071  470.652  0.000  0.00000  0.00000
## 1 | SubjectID -30.071  433.801 36.850  0.07830  0.07731
## mean_brake   -31.810  433.817 36.835  0.07826  0.07740

```

```

## mean_steering -33.597 433.829 36.823 0.07824 0.07750
## -----
Step-13 Mixed selection or Step-wise Regression
ols_step_both_aic(model, details = TRUE)

## Stepwise Selection Method
## -----
## 
## Candidate Terms:
## 
## 1 . mean_speed
## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . mean_brake
## 6 . sd_brake
## 7 . mean_steering
## 8 . sd_steering
## 9 . 1 | SubjectID
## 
## Step 0: AIC = 562.0742
## log_delta_pp ~ 1
## 
## 
## Variables Entered/Removed:
## 
##                               Enter New Variables
## -----
## Variable      DF   AIC   Sum Sq    RSS   R-Sq   Adj. R-Sq
## 
## mean_speed    1   97.352  28.547  442.105  0.061   0.061
## mean_brake    1  295.829  16.625  454.027  0.035   0.035
## mean_acc      1  357.545  12.853  457.799  0.027   0.027
## sd_steering   1  499.099   4.082  466.570  0.009   0.009
## sd_acc        1  500.467   3.996  466.655  0.008   0.008
## mean_steering 1  514.957   3.089  467.563  0.007   0.006
## sd_speed       1  547.892   1.020  469.632  0.002   0.002
## sd_brake       1  562.248   0.115  470.537  0.000   0.000
## 1 | SubjectID 1  564.074   0.000  470.652  0.000   0.000
## -----
## 
## - mean_speed added
## 
## 
## Step 1 : AIC = 97.35157
## log_delta_pp ~ mean_speed
## 
##                               Enter New Variables
## -----
## Variable      DF   AIC   Sum Sq    RSS   R-Sq   Adj. R-Sq
## 
## sd_brake      1   55.578  31.134  439.518  0.066   0.066
## sd_steering   1   63.127  30.689  439.963  0.065   0.065

```

```

## sd_acc          1    93.977    28.866    441.786    0.061    0.061
## sd_speed       1    96.298    28.728    441.924    0.061    0.061
## mean_steering  1    97.109    28.680    441.972    0.061    0.061
## mean_acc        1    97.782    28.640    442.012    0.061    0.061
## mean_brake      1    99.311    28.549    442.102    0.061    0.060
## 1 | SubjectID   1    564.074    0.000    470.652    0.000    0.000
##
## -----
## 
## - sd_brake added
## 
## 
## Step 2 : AIC = 55.57804
## log_delta_pp ~ mean_speed + sd_brake
## 
## Remove Existing Variables
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## sd_brake     1    97.352   28.547   442.105   0.061   0.061
## mean_speed   1    562.248   0.115   470.537   0.000   0.000
## 
## -----
## 
## Enter New Variables
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## sd_steering  1    0.117   34.507   436.145   0.073   0.073
## sd_speed     1    48.784   31.652   439.000   0.067   0.067
## mean_acc     1    53.760   31.359   439.293   0.067   0.066
## sd_acc       1    55.743   31.242   439.410   0.066   0.066
## mean_steering 1    56.541   31.195   439.457   0.066   0.066
## mean_brake   1    57.278   31.152   439.500   0.066   0.066
## 1 | SubjectID 1    564.074   0.000   470.652   0.000   0.000
## 
## -----
## 
## - sd_steering added
## 
## 
## Step 3 : AIC = 0.1168103
## log_delta_pp ~ mean_speed + sd_brake + sd_steering
## 
## Remove Existing Variables
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## sd_steering  1    55.578   31.134   439.518   0.066   0.066
## sd_brake     1    63.127   30.689   439.963   0.065   0.065
## mean_speed   1    500.835   4.099   466.553   0.009   0.008
## 
## -----
## 
## Enter New Variables
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## 
```

```

## mean_acc      1   -10.577    35.248    435.403    0.075    0.074
## sd_speed     1    -7.891    35.092    435.560    0.075    0.074
## mean_brake   1    -2.931    34.802    435.850    0.074    0.073
## sd_acc       1     1.519    34.542    436.110    0.073    0.073
## mean_steering 1     2.056    34.510    436.141    0.073    0.073
## 1 | SubjectID 1    564.074    0.000    470.652    0.000    0.000
##
## -----
## 
## - mean_acc added
## 
## 
## Step 4 : AIC = -10.57713
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc
## 
## Remove Existing Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## 
## mean_acc 1 0.117 34.507 436.145 0.073 0.073
## sd_steering 1 53.760 31.359 439.293 0.067 0.066
## sd_brake 1 59.642 31.012 439.639 0.066 0.066
## mean_speed 1 245.237 19.936 450.716 0.042 0.042
## 
## -----
## 
## Enter New Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## 
## sd_speed 1 -25.250 36.221 434.431 0.077 0.076
## sd_acc 1 -18.706 35.839 434.812 0.076 0.076
## mean_steering 1 -9.286 35.290 435.362 0.075 0.074
## mean_brake 1 -8.821 35.263 435.389 0.075 0.074
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## 
## -----
## 
## - sd_speed added
## 
## 
## Step 5 : AIC = -25.24999
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed
## 
## Remove Existing Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## 
## sd_speed 1 -10.577 35.248 435.403 0.075 0.074
## mean_acc 1 -7.891 35.092 435.560 0.075 0.074
## sd_steering 1 43.686 32.069 438.582 0.068 0.068
## sd_brake 1 56.698 31.304 439.348 0.067 0.066
## mean_speed 1 199.900 22.787 447.864 0.048 0.048
## 
## -----
## 
## Enter New Variables
## -----

```

```

## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_acc 1 -33.597 36.823 433.829 0.078 0.077
## mean_steering 1 -23.432 36.231 434.421 0.077 0.076
## mean_brake 1 -23.266 36.222 434.430 0.077 0.076
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## - sd_acc added
## 
## 
## Step 6 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed + sd_acc
## 
## Remove Existing Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_acc 1 -25.250 36.221 434.431 0.077 0.076
## sd_speed 1 -18.706 35.839 434.812 0.076 0.076
## mean_acc 1 -6.060 35.101 435.550 0.075 0.074
## sd_steering 1 37.393 32.557 438.095 0.069 0.069
## sd_brake 1 54.570 31.547 439.105 0.067 0.066
## mean_speed 1 200.081 22.897 447.755 0.049 0.048
## -----
## 
## Enter New Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_steering 1 -31.810 36.835 433.817 0.078 0.077
## mean_brake 1 -31.806 36.835 433.817 0.078 0.077
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## 
## No more variables to be added or removed.
## 
## Final Model Output
## -----
## 
## Model Summary
## -----
## R 0.280 RMSE 0.241
## R-Squared 0.078 Coef. Var 203.625
## Adj. R-Squared 0.077 MSE 0.058
## Pred R-Squared 0.076 MAE 0.189
## 
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
## 
## ANOVA
## -----

```

```

##               Sum of
##                 Squares      DF   Mean Square       F      Sig.
## -----
## Regression    36.823        6     6.137  105.419  0.0000
## Residual     433.829    7452     0.058
## Total         470.652    7458
## -----
## 
## 
##               Parameter Estimates
## -----
##      model    Beta  Std. Error  Std. Beta      t      Sig    lower   upper
## -----
## (Intercept) -0.110      0.020          -5.592  0.000  -0.148  -0.071
## mean_speed   0.002      0.000      0.234  15.467  0.000   0.002   0.002
## sd_brake     0.006      0.001      0.176  9.520  0.000   0.005   0.008
## sd_steering  -0.002     0.000     -0.100 -8.560  0.000  -0.002  -0.001
## mean_acc     0.004      0.001      0.096  5.438  0.000   0.003   0.006
## sd_speed     -0.002     0.000     -0.062 -4.110  0.000  -0.003  -0.001
## sd_acc       -0.004     0.001     -0.052 -3.216  0.001  -0.006  -0.002
## 
## 
##               Stepwise Summary
## -----
## Variable      Method      AIC      RSS     Sum Sq    R-Sq    Adj. R-Sq
## -----
## mean_speed    addition  97.352  442.105  28.547  0.06065  0.06053
## sd_brake      addition  55.578  439.518  31.134  0.06615  0.06590
## sd_steering   addition  0.117  436.145  34.507  0.07332  0.07294
## mean_acc      addition -10.577 435.403  35.248  0.07489  0.07440
## sd_speed      addition -25.250 434.431  36.221  0.07696  0.07634
## sd_acc        addition -33.597 433.829  36.823  0.07824  0.07750
## 

```

Step-14 Eliminating the highest vif value (mean_brake) and performing multi linear regression. Later, calculating the vif values.

```

model2 <- lm(log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc +
               sd_brake + mean_steering + sd_steering + (1|SubjectID) ,
               data = final)
ols_vif_tol(model2)

##           Variables Tolerance      VIF
## 1      mean_speed 0.5282958 1.892879
## 2      sd_speed 0.5401408 1.851369
## 3      mean_acc 0.3889257 2.571185
## 4      sd_acc 0.4748946 2.105730
## 5      sd_brake 0.3595399 2.781332
## 6      mean_steering 0.8665775 1.153965
## 7      sd_steering 0.8692763 1.150382
## 8 1 | SubjectIDTRUE 0.5000088 1.999965

```

Step-15 Step-wise Forward Regression on model2

```

ols_step_forward_aic(model2, details = TRUE)

## Forward Selection Method
## -----
## 
## Candidate Terms:
## 
## 1 . mean_speed
## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . sd_brake
## 6 . mean_steering
## 7 . sd_steering
## 8 . 1 | SubjectID
## 
## Step 0: AIC = 562.0742
## log_delta_pp ~ 1
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_speed 1 97.352 28.547 442.105 0.061 0.061
## mean_acc 1 357.545 12.853 457.799 0.027 0.027
## sd_steering 1 499.099 4.082 466.570 0.009 0.009
## sd_acc 1 500.467 3.996 466.655 0.008 0.008
## mean_steering 1 514.957 3.089 467.563 0.007 0.006
## sd_speed 1 547.892 1.020 469.632 0.002 0.002
## sd_brake 1 562.248 0.115 470.537 0.000 0.000
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## - mean_speed
## 
## 
## Step 1 : AIC = 97.35157
## log_delta_pp ~ mean_speed
## 
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_brake 1 55.578 2.587 439.518 0.066 0.066
## sd_steering 1 63.127 2.142 439.963 0.065 0.065
## sd_acc 1 93.977 0.318 441.786 0.061 0.061
## sd_speed 1 96.298 0.181 441.924 0.061 0.061
## mean_steering 1 97.109 0.133 441.972 0.061 0.061
## mean_acc 1 97.782 0.093 442.012 0.061 0.061
## 1 | SubjectID 1 564.074 -28.547 470.652 0.000 0.000
## -----
## 
## - sd_brake
## 
## 

```

```

## Step 2 : AIC = 55.57804
## log_delta_pp ~ mean_speed + sd_brake
##
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_steering 1 0.117 3.373 436.145 0.073 0.073
## sd_speed 1 48.784 0.518 439.000 0.067 0.067
## mean_acc 1 53.760 0.225 439.293 0.067 0.066
## sd_acc 1 55.743 0.108 439.410 0.066 0.066
## mean_steering 1 56.541 0.061 439.457 0.066 0.066
## 1 | SubjectID 1 564.074 -31.134 470.652 0.000 0.000
## -----
## -
## - sd_steering
## -
## -
## Step 3 : AIC = 0.1168103
## log_delta_pp ~ mean_speed + sd_brake + sd_steering
## -
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_acc 1 -10.577 0.742 435.403 0.075 0.074
## sd_speed 1 -7.891 0.585 435.560 0.075 0.074
## sd_acc 1 1.519 0.035 436.110 0.073 0.073
## mean_steering 1 2.056 0.004 436.141 0.073 0.073
## 1 | SubjectID 1 564.074 -34.507 470.652 0.000 0.000
## -----
## -
## - mean_acc
## -
## -
## Step 4 : AIC = -10.57713
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc
## -
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_speed 1 -25.250 0.972 434.431 0.077 0.076
## sd_acc 1 -18.706 0.591 434.812 0.076 0.076
## mean_steering 1 -9.286 0.041 435.362 0.075 0.074
## 1 | SubjectID 1 564.074 -35.248 470.652 0.000 0.000
## -----
## -
## - sd_speed
## -
## -
## Step 5 : AIC = -25.24999
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed
## -
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----

```

```

## sd_acc          1   -33.597     0.602    433.829    0.078     0.077
## mean_steering  1   -23.432     0.011    434.421    0.077     0.076
## 1 | SubjectID  1   564.074   -36.221    470.652    0.000     0.000
## -----
## 
## - sd_acc
## 
## 
## Step 6 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed + sd_acc
## 
## -----
## Variable       DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## mean_steering  1   -31.810     0.012    433.817    0.078     0.077
## 1 | SubjectID  1   564.074   -36.823    470.652    0.000     0.000
## -----
## 
## 
## No more variables to be added.
## 
## Variables Entered:
## 
## - mean_speed
## - sd_brake
## - sd_steering
## - mean_acc
## - sd_speed
## - sd_acc
## 
## 
## Final Model Output
## -----
## 
##                               Model Summary
## -----
## R                      0.280      RMSE           0.241
## R-Squared               0.078      Coef. Var     203.625
## Adj. R-Squared          0.077      MSE            0.058
## Pred R-Squared          0.076      MAE            0.189
## -----
## 
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
## 
##                               ANOVA
## -----
## 
##             Sum of
##             Squares      DF      Mean Square      F      Sig.
## 
## Regression        36.823      6       6.137    105.419    0.0000
## Residual         433.829    7452      0.058
## Total            470.652    7458
## -----

```

```

##                                     Parameter Estimates
## -----
##      model      Beta   Std. Error   Std. Beta      t     Sig    lower   upper
## -----
## (Intercept) -0.110       0.020          -5.592  0.000 -0.148 -0.071
## mean_speed   0.002       0.000       0.234  15.467  0.000  0.002  0.002
## sd_brake     0.006       0.001       0.176  9.520  0.000  0.005  0.008
## sd_steering  -0.002      0.000      -0.100 -8.560  0.000 -0.002 -0.001
## mean_acc     0.004       0.001       0.096  5.438  0.000  0.003  0.006
## sd_speed     -0.002      0.000      -0.062 -4.110  0.000 -0.003 -0.001
## sd_acc       -0.004      0.001      -0.052 -3.216  0.001 -0.006 -0.002
## -----
##                                     Selection Summary
## -----
## Variable      AIC     Sum Sq     RSS     R-Sq     Adj. R-Sq
## -----
## mean_speed    97.352  28.547  442.105  0.06065  0.06053
## sd_brake     55.578  31.134  439.518  0.06615  0.06590
## sd_steering   0.117  34.507  436.145  0.07332  0.07294
## mean_acc     -10.577 35.248  435.403  0.07489  0.07440
## sd_speed     -25.250 36.221  434.431  0.07696  0.07634
## sd_acc       -33.597 36.823  433.829  0.07824  0.07750
## -----

```

Step-16 Step-wise Backward Regression on model2

```
ols_step_backward_aic(model2, details = TRUE)
```

```

## Backward Elimination Method
## -----
## 
## Candidate Terms:
## 
## 1 . mean_speed
## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . sd_brake
## 6 . mean_steering
## 7 . sd_steering
## 8 . 1 | SubjectID
## 
## Step 0: AIC = -29.80972
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + sd_brake + mean_steering + sd_steering +
## 
## -----
## Variable      DF     AIC     Sum Sq     RSS     R-Sq     Adj. R-Sq
## -----
## 1 | SubjectID 1    -31.810  -36.835  433.817  0.078    0.077
## mean_speed    1    564.074   0.000   470.652  0.000    0.000
## sd_speed      1    564.074   0.000   470.652  0.000    0.000
## mean_acc      1    564.074   0.000   470.652  0.000    0.000
## sd_acc        1    564.074   0.000   470.652  0.000    0.000
## 
```

```

## sd_brake      1    564.074    0.000   470.652    0.000    0.000
## mean_steering 1    564.074    0.000   470.652    0.000    0.000
## sd_steering   1    564.074    0.000   470.652    0.000    0.000
## -----
## 
## 
## Variables Removed:
## 
## - 1 | SubjectID
## 
## 
## Step 1 : AIC = -31.80972
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + sd_brake + mean_steering + sd_steering
## 
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## mean_steering 1   -33.597   0.012  433.829   0.078   0.077
## sd_acc        1   -23.432   0.604  434.421   0.077   0.076
## sd_speed      1   -17.479   0.951  434.767   0.076   0.076
## mean_acc       1   -4.104   1.731  435.548   0.075   0.074
## sd_steering   1    38.007   4.197  438.014   0.069   0.069
## sd_brake      1    56.560   5.288  439.104   0.067   0.066
## mean_speed    1   198.951  13.751 447.567   0.049   0.048
## -----
## 
## 
## - mean_steering
## 
## 
## Step 2 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_speed + mean_acc + sd_acc + sd_brake + sd_steering
## 
## -----
## Variable     DF   AIC   Sum Sq   RSS   R-Sq   Adj. R-Sq
## -----
## sd_acc        1   -25.250   0.602  434.431   0.077   0.076
## sd_speed      1   -18.706   0.983  434.812   0.076   0.076
## mean_acc       1   -6.060   1.721  435.550   0.075   0.074
## sd_steering   1    37.393   4.266  438.095   0.069   0.069
## sd_brake      1    54.570   5.276  439.105   0.067   0.066
## mean_speed    1   200.081  13.926 447.755   0.049   0.048
## -----
## 
## 
## No more variables to be removed.
## 
## 
## Variables Removed:
## 
## - 1 | SubjectID
## - mean_steering
## 
## 
## Final Model Output
## -----

```

```

## Model Summary
## -----
## R 0.280 RMSE 0.241
## R-Squared 0.078 Coef. Var 203.625
## Adj. R-Squared 0.077 MSE 0.058
## Pred R-Squared 0.076 MAE 0.189
## -----
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
## ANOVA
## -----
## Sum of
## Squares DF Mean Square F Sig.
## -----
## Regression 36.823 6 6.137 105.419 0.0000
## Residual 433.829 7452 0.058
## Total 470.652 7458
## -----
## Parameter Estimates
## -----
## model Beta Std. Error Std. Beta t Sig lower upper
## -----
## (Intercept) -0.110 0.020 -5.592 0.000 -0.148 -0.071
## mean_speed 0.002 0.000 0.234 15.467 0.000 0.002 0.002
## sd_speed -0.002 0.000 -0.062 -4.110 0.000 -0.003 -0.001
## mean_acc 0.004 0.001 0.096 5.438 0.000 0.003 0.006
## sd_acc -0.004 0.001 -0.052 -3.216 0.001 -0.006 -0.002
## sd_brake 0.006 0.001 0.176 9.520 0.000 0.005 0.008
## sd_steering -0.002 0.000 -0.100 -8.560 0.000 -0.002 -0.001
## -----
## Backward Elimination Summary
## -----
## Variable AIC RSS Sum Sq R-Sq Adj. R-Sq
## -----
## Full Model -29.810 470.652 0.000 0.00000 0.00000
## 1 | SubjectID -31.810 433.817 36.835 0.07826 0.07740
## mean_steering -33.597 433.829 36.823 0.07824 0.07750
## -----

```

Step-17 Mixed selection or Step-wise Regression on model2

```
ols_step_both_aic(model2, details = TRUE)
```

```

## Stepwise Selection Method
## -----
## Candidate Terms:
## 
## 1 . mean_speed

```

```

## 2 . sd_speed
## 3 . mean_acc
## 4 . sd_acc
## 5 . sd_brake
## 6 . mean_steering
## 7 . sd_steering
## 8 . 1 | SubjectID
##
## Step 0: AIC = 562.0742
## log_delta_pp ~ 1
##
##
## Variables Entered/Removed:
##
##                                Enter New Variables
## -----
##   Variable      DF      AIC     Sum Sq      RSS      R-Sq    Adj. R-Sq
## -----
##   mean_speed    1    97.352    28.547    442.105    0.061    0.061
##   mean_acc     1   357.545   12.853    457.799    0.027    0.027
##   sd_steering   1   499.099    4.082    466.570    0.009    0.009
##   sd_acc        1   500.467    3.996    466.655    0.008    0.008
##   mean_steering 1   514.957    3.089    467.563    0.007    0.006
##   sd_speed       1   547.892    1.020    469.632    0.002    0.002
##   sd_brake       1   562.248    0.115    470.537    0.000    0.000
##   1 | SubjectID  1   564.074    0.000    470.652    0.000    0.000
## -----
##
##
## - mean_speed added
##
##
## Step 1 : AIC = 97.35157
## log_delta_pp ~ mean_speed
##
##                                Enter New Variables
## -----
##   Variable      DF      AIC     Sum Sq      RSS      R-Sq    Adj. R-Sq
## -----
##   sd_brake      1    55.578    31.134    439.518    0.066    0.066
##   sd_steering   1    63.127    30.689    439.963    0.065    0.065
##   sd_acc        1    93.977    28.866    441.786    0.061    0.061
##   sd_speed       1    96.298    28.728    441.924    0.061    0.061
##   mean_steering 1    97.109    28.680    441.972    0.061    0.061
##   mean_acc       1    97.782    28.640    442.012    0.061    0.061
##   1 | SubjectID  1   564.074    0.000    470.652    0.000    0.000
## -----
##
##
## - sd_brake added
##
##
## Step 2 : AIC = 55.57804
## log_delta_pp ~ mean_speed + sd_brake
##
##                                Remove Existing Variables

```

```

## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_brake 1 97.352 28.547 442.105 0.061 0.061
## mean_speed 1 562.248 0.115 470.537 0.000 0.000
## -----
## 
## Enter New Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_steering 1 0.117 34.507 436.145 0.073 0.073
## sd_speed 1 48.784 31.652 439.000 0.067 0.067
## mean_acc 1 53.760 31.359 439.293 0.067 0.066
## sd_acc 1 55.743 31.242 439.410 0.066 0.066
## mean_steering 1 56.541 31.195 439.457 0.066 0.066
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## - sd_steering added
## 
## 
## Step 3 : AIC = 0.1168103
## log_delta_pp ~ mean_speed + sd_brake + sd_steering
## 
## Remove Existing Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## sd_steering 1 55.578 31.134 439.518 0.066 0.066
## sd_brake 1 63.127 30.689 439.963 0.065 0.065
## mean_speed 1 500.835 4.099 466.553 0.009 0.008
## -----
## 
## Enter New Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq
## -----
## mean_acc 1 -10.577 35.248 435.403 0.075 0.074
## sd_speed 1 -7.891 35.092 435.560 0.075 0.074
## sd_acc 1 1.519 34.542 436.110 0.073 0.073
## mean_steering 1 2.056 34.510 436.141 0.073 0.073
## 1 | SubjectID 1 564.074 0.000 470.652 0.000 0.000
## -----
## 
## - mean_acc added
## 
## 
## Step 4 : AIC = -10.57713
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc
## 
## Remove Existing Variables
## -----
## Variable DF AIC Sum Sq RSS R-Sq Adj. R-Sq

```

```

## -----
## mean_acc      1     0.117    34.507    436.145    0.073    0.073
## sd_steering   1    53.760    31.359    439.293    0.067    0.066
## sd_brake      1    59.642    31.012    439.639    0.066    0.066
## mean_speed    1   245.237    19.936    450.716    0.042    0.042
## -----
## 
## 
## Enter New Variables
## -----
## Variable      DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## sd_speed      1   -25.250    36.221    434.431    0.077    0.076
## sd_acc        1   -18.706    35.839    434.812    0.076    0.076
## mean_steering 1   -9.286    35.290    435.362    0.075    0.074
## 1 | SubjectID 1   564.074    0.000    470.652    0.000    0.000
## -----
## 
## 
## - sd_speed added
## 
## 
## Step 5 : AIC = -25.24999
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed
## 
## Remove Existing Variables
## -----
## Variable      DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## sd_speed      1   -10.577    35.248    435.403    0.075    0.074
## mean_acc      1   -7.891    35.092    435.560    0.075    0.074
## sd_steering   1    43.686    32.069    438.582    0.068    0.068
## sd_brake      1    56.698    31.304    439.348    0.067    0.066
## mean_speed    1   199.900    22.787    447.864    0.048    0.048
## -----
## 
## 
## Enter New Variables
## -----
## Variable      DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## sd_acc        1   -33.597    36.823    433.829    0.078    0.077
## mean_steering 1   -23.432    36.231    434.421    0.077    0.076
## 1 | SubjectID 1   564.074    0.000    470.652    0.000    0.000
## -----
## 
## 
## - sd_acc added
## 
## 
## Step 6 : AIC = -33.5966
## log_delta_pp ~ mean_speed + sd_brake + sd_steering + mean_acc + sd_speed + sd_acc
## 
## Remove Existing Variables
## -----
## Variable      DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## sd_acc        1   -25.250    36.221    434.431    0.077    0.076

```

```

## sd_speed      1   -18.706   35.839   434.812   0.076   0.076
## mean_acc     1    -6.060   35.101   435.550   0.075   0.074
## sd_steering   1   37.393   32.557   438.095   0.069   0.069
## sd_brake      1   54.570   31.547   439.105   0.067   0.066
## mean_speed    1  200.081   22.897   447.755   0.049   0.048
##
## -----
## 
## Enter New Variables
## -----
## Variable       DF      AIC      Sum Sq      RSS      R-Sq      Adj. R-Sq
## -----
## mean_steering  1   -31.810   36.835   433.817   0.078   0.077
## 1 | SubjectID  1   564.074   0.000   470.652   0.000   0.000
##
## -----
## 
## 
## No more variables to be added or removed.
##
## Final Model Output
## -----
## 
## Model Summary
## -----
## R              0.280      RMSE          0.241
## R-Squared      0.078      Coef. Var     203.625
## Adj. R-Squared 0.077      MSE            0.058
## Pred R-Squared 0.076      MAE            0.189
##
## RMSE: Root Mean Square Error
## MSE: Mean Square Error
## MAE: Mean Absolute Error
##
## ANOVA
## -----
##           Sum of
##           Squares      DF      Mean Square      F      Sig.
## -----
## Regression   36.823      6       6.137   105.419   0.0000
## Residual    433.829    7452      0.058
## Total        470.652    7458
##
## -----
## 
## Parameter Estimates
## -----
##   model      Beta  Std. Error  Std. Beta      t      Sig      lower      upper
## -----
## (Intercept) -0.110      0.020          -5.592  0.000  -0.148  -0.071
## mean_speed   0.002      0.000      0.234   15.467  0.000   0.002   0.002
## sd_brake     0.006      0.001      0.176    9.520  0.000   0.005   0.008
## sd_steering  -0.002     0.000     -0.100   -8.560  0.000  -0.002  -0.001
## mean_acc     0.004      0.001      0.096    5.438  0.000   0.003   0.006
## sd_speed     -0.002     0.000     -0.062   -4.110  0.000  -0.003  -0.001
## sd_acc       -0.004     0.001     -0.052   -3.216  0.001  -0.006  -0.002
##

```

```

## 
## 
##                               Stepwise Summary
## -----
##   Variable      Method      AIC      RSS      Sum Sq      R-Sq      Adj. R-Sq
## 
##   mean_speed   addition   97.352   442.105   28.547   0.06065   0.06053
##   sd_brake     addition   55.578   439.518   31.134   0.06615   0.06590
##   sd_steering  addition   0.117    436.145   34.507   0.07332   0.07294
##   mean_acc     addition  -10.577   435.403   35.248   0.07489   0.07440
##   sd_speed     addition  -25.250   434.431   36.221   0.07696   0.07634
##   sd_acc       addition  -33.597   433.829   36.823   0.07824   0.07750
## 
## -----

```

Observations and Inferences

- 1) As we can see from the qq plots, log transformed values are normalized than the original values. So, we are considering log_delta_pp as the responsive variable.
- 2) When we checked the vif values of the model with all the features, we can clearly see that mean_brake has highest vif value (3.769341). So, removing the mean_brake will eliminate the multi collinearity from the model. The highest vif value is the culprit for multi collinearity.
- 3) All the three selection methods have the same AIC value at the last step (-33.5966)
- 4) In the forward selection model, model starts with null model and it has AIC 562.0742. At the end of 6 steps, the model has AIC -33.5966.
- 5) In the backward selection model, model started with full model and it has AIC -29.80972. At the end of 2 stpes, the model has AIC -33.5966.
- 6) In the mixed selection model, the model started with AIC 562.0742 and at the end of 6 steps, model has AIC -33.5966.
- 7) mean_brake is collinear with sd_brake.
- 8) AIC value before removing mean_brake and after removing mean_brake is didnt change, AIC(-33.5966) remained unchanged. **9)** In FS model, sd_acc (sd of acceleerator) has the highest R^2 value, so we can consider it as the significant variable.
- 10) Also, the least RSS in FS model is sd_acc. This strongly suggests that sd_acc is the significant model.
- 11) In backward selection model, the lowest RSS increase is from 433.817 (1|s) to 433.829 (mean_steering).
- 12) In backward selection model, the lowest R^2 is between 1|S and mean_steering.
- 13) Variables removed in backward model are 1|S and mean_steering, so, we can conclude that those two are least significant variables.