```r
library(rpart)
library("rpart.plot")
library(ROCR)
library(randomForest)
```

```
## randomForest 4.7-1.1
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```r
library(gbm)
```

```
## Loaded gbm 2.1.9
```

```
## This version of gbm is no longer under development. Consider transitioning to gbm3, https://github.c
```

```r
library(MASS)
```

```r
data <- read.csv("C:/Users/hp/Downloads/HMEQ_Scrubbed (3)/HMEQ_Scrubbed.csv")
str(data)
```

Step-1

```
## 'data.frame':    5960 obs. of  29 variables:
##  $ TARGET_BAD_FLAG  : int  1 1 1 1 0 1 1 1 1 1 ...
##  $ TARGET_LOSS_AMT  : int  641 1109 767 1425 0 335 1841 373 1217 1523 ...
##  $ LOAN             : int  1100 1300 1500 1500 1700 1700 1800 1800 2000 2000 ...
##  $ IMP_MORTDUE      : num  25860 70053 13500 65000 97800 ...
##  $ M_MORTDUE        : int  0 0 0 1 0 0 0 0 0 1 ...
##  $ IMP_VALUE        : num  39025 68400 16700 89000 112000 ...
##  $ M_VALUE          : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_YOJ          : num  10.5 7 4 7 3 9 5 11 3 16 ...
##  $ M_YOJ            : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_DEROG        : int  0 0 0 1 0 0 3 0 0 0 ...
##  $ M_DEROG          : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_DELINQ       : int  0 2 0 1 0 0 2 0 2 0 ...
##  $ M_DELINQ         : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_CLAGE        : num  94.4 121.8 149.5 174 93.3 ...
##  $ M_CLAGE          : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_NINQ         : int  1 0 1 1 0 1 1 0 1 0 ...
##  $ M_NINQ           : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_CLNO         : int  9 14 10 20 14 8 17 8 12 13 ...
##  $ M_CLNO           : int  0 0 0 1 0 0 0 0 0 0 ...
##  $ IMP_DEBTINC      : num  35 35 35 35 35 ...
##  $ M_DEBTINC        : int  1 1 1 1 1 0 1 0 1 1 ...
##  $ FLAG.Job.Mgr     : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ FLAG.Job.Office  : int  0 0 0 0 1 0 0 0 0 0 ...
##  $ FLAG.Job.Other   : int  1 1 1 0 0 1 1 1 1 0 ...
##  $ FLAG.Job.ProfExe : int  0 0 0 0 0 0 0 0 0 0 ...
```

```
## $ FLAG.Job.Sales    : int  0 0 0 0 0 0 0 0 0 1 ...
## $ FLAG.Job.Self     : int  0 0 0 0 0 0 0 0 0 0 ...
## $ FLAG.Reason.DebtCon: int  0 0 0 0 0 0 0 0 0 0 ...
## $ FLAG.Reason.HomeImp: int  1 1 1 0 1 1 1 1 1 1 ...
```

summary(data)

```
##  TARGET_BAD_FLAG TARGET_LOSS_AMT      LOAN         IMP_MORTDUE
##  Min.   :0.0000  Min.   :    0   Min.   : 1100   Min.   :  2063
##  1st Qu.:0.0000  1st Qu.:    0   1st Qu.:11100   1st Qu.: 48139
##  Median :0.0000  Median :    0   Median :16300   Median : 65000
##  Mean   :0.1995  Mean   : 2676   Mean   :18608   Mean   : 72999
##  3rd Qu.:0.0000  3rd Qu.:    0   3rd Qu.:23300   3rd Qu.: 88200
##  Max.   :1.0000  Max.   :78987   Max.   :89900   Max.   :399550
##    M_MORTDUE        IMP_VALUE        M_VALUE          IMP_YOJ
##  Min.   :0.00000  Min.   :  8000  Min.   :0.00000  Min.   : 0.000
##  1st Qu.:0.00000  1st Qu.: 66490  1st Qu.:0.00000  1st Qu.: 3.000
##  Median :0.00000  Median : 89000  Median :0.00000  Median : 7.000
##  Mean   :0.08691  Mean   :101536  Mean   :0.01879  Mean   : 8.756
##  3rd Qu.:0.00000  3rd Qu.:119005  3rd Qu.:0.00000  3rd Qu.:12.000
##  Max.   :1.00000  Max.   :855909  Max.   :1.00000  Max.   :41.000
##     M_YOJ           IMP_DEROG        M_DEROG          IMP_DELINQ
##  Min.   :0.00000  Min.   : 0.0000  Min.   :0.0000   Min.   : 0.000
##  1st Qu.:0.00000  1st Qu.: 0.0000  1st Qu.:0.0000   1st Qu.: 0.000
##  Median :0.00000  Median : 0.0000  Median :0.0000   Median : 0.000
##  Mean   :0.08641  Mean   : 0.3431  Mean   :0.1188   Mean   : 0.503
##  3rd Qu.:0.00000  3rd Qu.: 0.0000  3rd Qu.:0.0000   3rd Qu.: 1.000
##  Max.   :1.00000  Max.   :10.0000  Max.   :1.0000   Max.   :15.000
##    M_DELINQ         IMP_CLAGE        M_CLAGE          IMP_NINQ
##  Min.   :0.00000  Min.   :   0.0  Min.   :0.00000  Min.   : 0.00
##  1st Qu.:0.00000  1st Qu.: 117.4  1st Qu.:0.00000  1st Qu.: 0.00
##  Median :0.00000  Median : 174.0  Median :0.00000  Median : 1.00
##  Mean   :0.09732  Mean   : 179.5  Mean   :0.05168  Mean   : 1.17
##  3rd Qu.:0.00000  3rd Qu.: 227.1  3rd Qu.:0.00000  3rd Qu.: 2.00
##  Max.   :1.00000  Max.   :1168.2  Max.   :1.00000  Max.   :17.00
##     M_NINQ          IMP_CLNO         M_CLNO          IMP_DEBTINC
##  Min.   :0.00000  Min.   : 0.00  Min.   :0.00000  Min.   :  0.5245
##  1st Qu.:0.00000  1st Qu.:15.00  1st Qu.:0.00000  1st Qu.: 30.7632
##  Median :0.00000  Median :20.00  Median :0.00000  Median : 35.0000
##  Mean   :0.08557  Mean   :21.25  Mean   :0.03725  Mean   : 34.0393
##  3rd Qu.:0.00000  3rd Qu.:26.00  3rd Qu.:0.00000  3rd Qu.: 37.9499
##  Max.   :1.00000  Max.   :71.00  Max.   :1.00000  Max.   :203.3122
##    M_DEBTINC        FLAG.Job.Mgr     FLAG.Job.Office  FLAG.Job.Other
##  Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.0000   Median :0.0000   Median :0.0000   Median :0.0000
##  Mean   :0.2126   Mean   :0.1287   Mean   :0.1591   Mean   :0.4007
##  3rd Qu.:0.0000   3rd Qu.:0.0000   3rd Qu.:0.0000   3rd Qu.:1.0000
##  Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
##  FLAG.Job.ProfExe FLAG.Job.Sales   FLAG.Job.Self    FLAG.Reason.DebtCon
##  Min.   :0.0000   Min.   :0.00000  Min.   :0.00000  Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.0000
##  Median :0.0000   Median :0.00000  Median :0.00000  Median :1.0000
##  Mean   :0.2141   Mean   :0.01829  Mean   :0.03238  Mean   :0.6591
```

```
##  3rd Qu.:0.0000    3rd Qu.:0.00000    3rd Qu.:0.00000    3rd Qu.:1.0000
##  Max.   :1.0000    Max.   :1.00000    Max.   :1.00000    Max.   :1.0000
##  FLAG.Reason.HomeImp
##  Min.   :0.0000
##  1st Qu.:0.0000
##  Median :0.0000
##  Mean   :0.2987
##  3rd Qu.:1.0000
##  Max.   :1.0000
```

```
head(data,6)
```

```
##   TARGET_BAD_FLAG TARGET_LOSS_AMT LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE
## 1               1             641 1100       25860         0     39025       0
## 2               1            1109 1300       70053         0     68400       0
## 3               1             767 1500       13500         0     16700       0
## 4               1            1425 1500       65000         1     89000       1
## 5               0               0 1700       97800         0    112000       0
## 6               1             335 1700       30548         0     40320       0
##   IMP_YOJ M_YOJ IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE
## 1    10.5     0         0       0          0        0  94.36667       0
## 2     7.0     0         0       0          2        0 121.83333       0
## 3     4.0     0         0       0          0        0 149.46667       0
## 4     7.0     1         1       1          1        1 174.00000       1
## 5     3.0     0         0       0          0        0  93.33333       0
## 6     9.0     0         0       0          0        0 101.46600       0
##   IMP_NINQ M_NINQ IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr
## 1        1      0        9      0    35.00000         1            0
## 2        0      0       14      0    35.00000         1            0
## 3        1      0       10      0    35.00000         1            0
## 4        1      1       20      1    35.00000         1            0
## 5        0      0       14      0    35.00000         1            0
## 6        1      0        8      0    37.11361         0            0
##   FLAG.Job.Office FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1               0              1                0              0             0
## 2               0              1                0              0             0
## 3               0              1                0              0             0
## 4               0              0                0              0             0
## 5               1              0                0              0             0
## 6               0              1                0              0             0
##   FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
## 2                   0                   1
## 3                   0                   1
## 4                   0                   0
## 5                   0                   1
## 6                   0                   1
```

STEP-2

```
SEED=1
set.seed(SEED)
```

```
data_flag= data
data_flag$TARGET_LOSS_AMT= NULL
head(data_flag)
```

```
##   TARGET_BAD_FLAG LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE IMP_YOJ M_YOJ
## 1               1 1100       25860         0     39025       0    10.5     0
## 2               1 1300       70053         0     68400       0     7.0     0
## 3               1 1500       13500         0     16700       0     4.0     0
## 4               1 1500       65000         1     89000       1     7.0     1
## 5               0 1700       97800         0    112000       0     3.0     0
## 6               1 1700       30548         0     40320       0     9.0     0
##   IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE IMP_NINQ M_NINQ
## 1         0       0          0        0  94.36667       0        1      0
## 2         0       0          2        0 121.83333       0        0      0
## 3         0       0          0        0 149.46667       0        1      0
## 4         1       1          1        1 174.00000       1        1      1
## 5         0       0          0        0  93.33333       0        0      0
## 6         0       0          0        0 101.46600       0        1      0
##   IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr FLAG.Job.Office
## 1        9      0    35.00000         1            0               0
## 2       14      0    35.00000         1            0               0
## 3       10      0    35.00000         1            0               0
## 4       20      1    35.00000         1            0               0
## 5       14      0    35.00000         1            0               1
## 6        8      0    37.11361         0            0               0
##   FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1              1                0              0             0
## 2              1                0              0             0
## 3              1                0              0             0
## 4              0                0              0             0
## 5              0                0              0             0
## 6              1                0              0             0
##   FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
## 2                   0                   1
## 3                   0                   1
## 4                   0                   0
## 5                   0                   1
## 6                   0                   1
```

```
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.7,0.3))
data_train= data_flag[FLAG, ]
data_test= data_flag[! FLAG, ]
```

```
dim(data_flag)
```

```
## [1] 5960   28
```

```
dim(data_train)
```

```
## [1] 4142   28
```
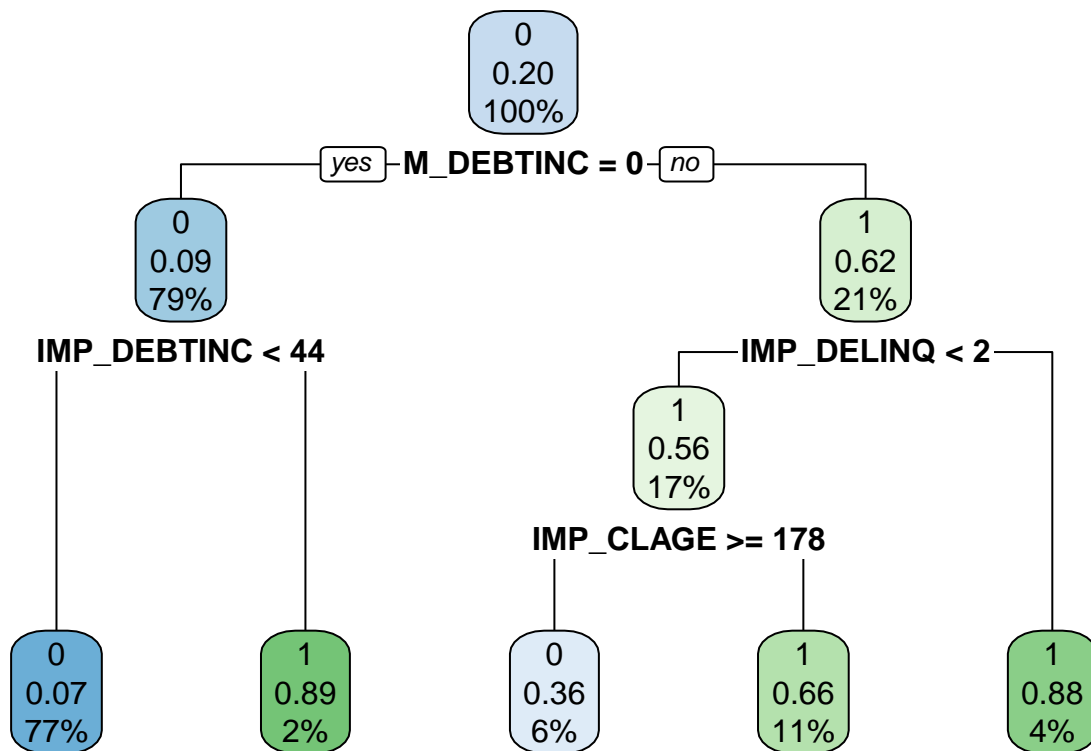
```
dim(data_test)
```

```
## [1] 1818    28
```

Decision Tree

```
tr_set=rpart.control(maxdepth=10)
t1E = rpart(data=data_train, TARGET_BAD_FLAG ~ ., control = tr_set, method = "class", parms = list(spli
```

```
rpart.plot(t1E)
```



```
t1E$variable.importance
```

```
##   M_DEBTINC IMP_DEBTINC  IMP_DELINQ   IMP_CLAGE        LOAN     M_VALUE
## 533.397481  134.588883   46.494397   30.749923   24.521888   22.199895
##   IMP_VALUE IMP_MORTDUE    IMP_CLNO     IMP_YOJ
##    7.967967    5.783975    2.459994    2.090995
```

```
pt = predict(t1E, data_test, type= "prob")
head(pt)
```

```
##            0          1
## 4   0.3354839 0.66451613
## 6   0.9315112 0.06848885
## 7   0.1206897 0.87931034
## 15  0.3354839 0.66451613
## 17  0.1206897 0.87931034
## 18  0.9315112 0.06848885
```

```
pt2 = prediction(pt[,2], data_test$TARGET_BAD_FLAG)
pt3 = performance(pt2, "tpr", "fpr")
```

```
pt = predict(t1E, data_test)
head(pt)
```

```
##            0          1
## 4   0.3354839 0.66451613
## 6   0.9315112 0.06848885
## 7   0.1206897 0.87931034
## 15  0.3354839 0.66451613
## 17  0.1206897 0.87931034
## 18  0.9315112 0.06848885
```

```
RMSEt = sqrt(mean((data_test$TARGET_BAD_FLAG - pt)^2))
```

```
rf_model = randomForest(data = data_train, TARGET_BAD_FLAG ~., ntree=500, importance= TRUE)
```

RF

```
## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values.  Are you sure you want to do regression?
```

```
importance(rf_model)
```

```
##                      %IncMSE IncNodePurity
## LOAN               44.967305     38.993106
## IMP_MORTDUE        41.789344     35.266432
## M_MORTDUE          13.172790      2.349943
## IMP_VALUE          42.571780     43.056864
## M_VALUE            59.462869     18.739138
## IMP_YOJ            40.432069     31.086101
## M_YOJ              14.199750      2.944031
## IMP_DEROG          45.717324     21.754538
## M_DEROG            18.473874      4.951353
## IMP_DELINQ         81.884902     48.238429
## M_DELINQ            8.547209      2.107158
## IMP_CLAGE          62.739262     55.559885
## M_CLAGE            11.726470      1.840701
## IMP_NINQ           34.906103     17.852157
```

```
## M_NINQ              12.162285       2.082765
## IMP_CLNO            53.442201      37.694496
## M_CLNO              11.739013       1.103966
## IMP_DEBTINC         35.982961     104.953372
## M_DEBTINC           38.536277     130.591066
## FLAG.Job.Mgr        17.040006       3.765830
## FLAG.Job.Office     17.467948       5.148490
## FLAG.Job.Other      18.895132       5.102794
## FLAG.Job.ProfExe    15.455256       3.935220
## FLAG.Job.Sales      23.675630       3.364372
## FLAG.Job.Self       12.098948       1.883075
## FLAG.Reason.DebtCon 15.811019       3.814255
## FLAG.Reason.HomeImp 14.617020       3.908644
```

```r
varImpPlot(rf_model)
```

rf_model
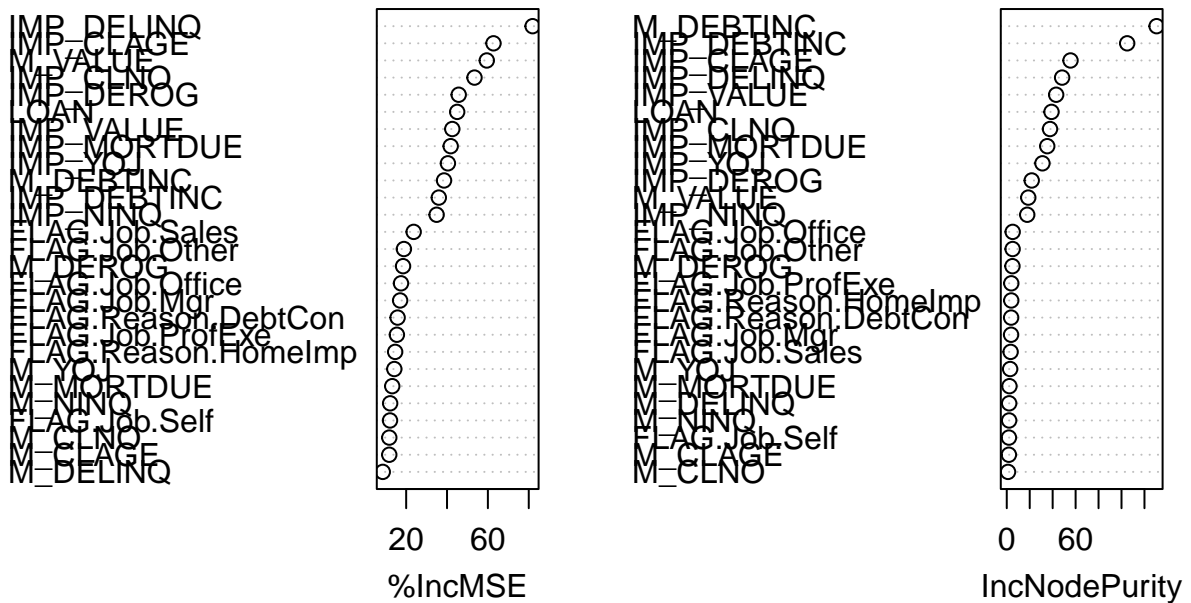

```r
pr= predict(rf_model, data_test)
head(pr)
```

```
##         4         6         7        15        17        18
## 0.7966524 0.8313333 0.9241667 0.7746333 0.9212667 0.3462000
```

```r
pr2= prediction(pr, data_test$TARGET_BAD_FLAG)
pr3= performance(pr2, "tpr", "fpr")
```

```
pr = predict(rf_model, data_test)
head(pr)
```

```
##         4         6         7        15        17        18
## 0.7966524 0.8313333 0.9241667 0.7746333 0.9212667 0.3462000
```

```
RMSEr = sqrt(mean((data_test$TARGET_BAD_FLAG - pr)^2))
```

```
gb_model = gbm(data=data_train, TARGET_BAD_FLAG ~., n.tree=500, distribution = "bernoulli")
summary.gbm(gb_model, cBars = 10)
```
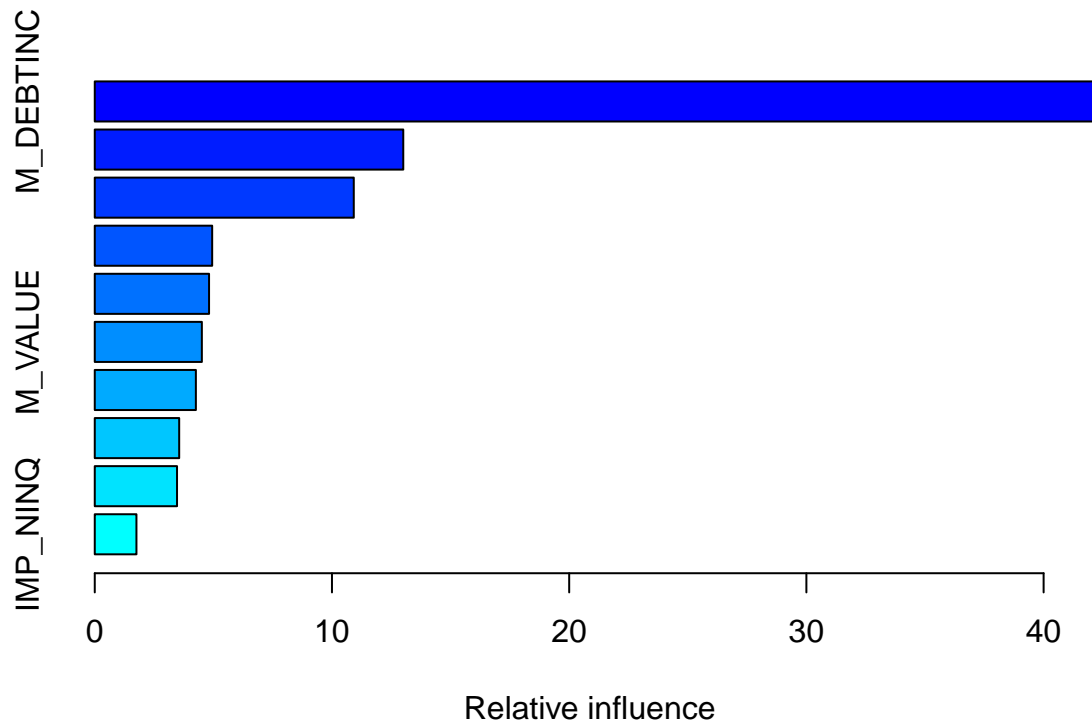

GB

```
##                            var     rel.inf
## M_DEBTINC            M_DEBTINC 42.15276212
## IMP_DEBTINC        IMP_DEBTINC 13.00578764
## IMP_DELINQ          IMP_DELINQ 10.91954001
## IMP_CLAGE            IMP_CLAGE  4.94970498
## IMP_VALUE            IMP_VALUE  4.81763715
## M_VALUE                M_VALUE  4.51409149
## IMP_DEROG            IMP_DEROG  4.26284516
## LOAN                      LOAN  3.55916423
## IMP_CLNO              IMP_CLNO  3.46797820
```

```
## IMP_NINQ                        IMP_NINQ  1.75727930
## IMP_YOJ                         IMP_YOJ   1.65837025
## IMP_MORTDUE                     IMP_MORTDUE 1.64426153
## M_DEROG                         M_DEROG   1.27305534
## FLAG.Job.Sales        FLAG.Job.Sales       0.73536853
## M_CLNO                          M_CLNO    0.54901563
## M_YOJ                           M_YOJ     0.16877535
## FLAG.Job.Other        FLAG.Job.Other       0.13372343
## FLAG.Job.Office       FLAG.Job.Office      0.12346471
## FLAG.Job.Mgr              FLAG.Job.Mgr     0.06870764
## FLAG.Reason.DebtCon FLAG.Reason.DebtCon   0.06701971
## M_DELINQ                        M_DELINQ  0.06598496
## M_MORTDUE                       M_MORTDUE 0.05293782
## FLAG.Job.Self           FLAG.Job.Self     0.05252482
## M_CLAGE                         M_CLAGE   0.00000000
## M_NINQ                          M_NINQ    0.00000000
## FLAG.Job.ProfExe       FLAG.Job.ProfExe   0.00000000
## FLAG.Reason.HomeImp FLAG.Reason.HomeImp   0.00000000
```

```r
pg = predict(gb_model, data_test)
```

```
## Using 500 trees...
```

```r
head(pg)
```

```
## [1]  3.367087 -0.272228  5.113228  1.428145  6.221386  3.551554
```

```r
RMSEg = sqrt(mean((data_test$TARGET_BAD_FLAG - pg)^2))
```

```r
pg= predict(gb_model, data_test, type= "response")
```

```
## Using 500 trees...
```

```r
head(pg)
```

```
## [1] 0.9666599 0.4323602 0.9940194 0.8066121 0.9980174 0.9721196
```

```r
pg2=prediction(pg, data_test$TARGET_BAD_FLAG)
pg3 = performance(pg2, "tpr", "fpr")
```

```r
plot(pt3, col= "green")
abline(0,1,lty=2)
legend("bottomright", c("TREE"), col=c("green"), bty="y", lty=1)
```
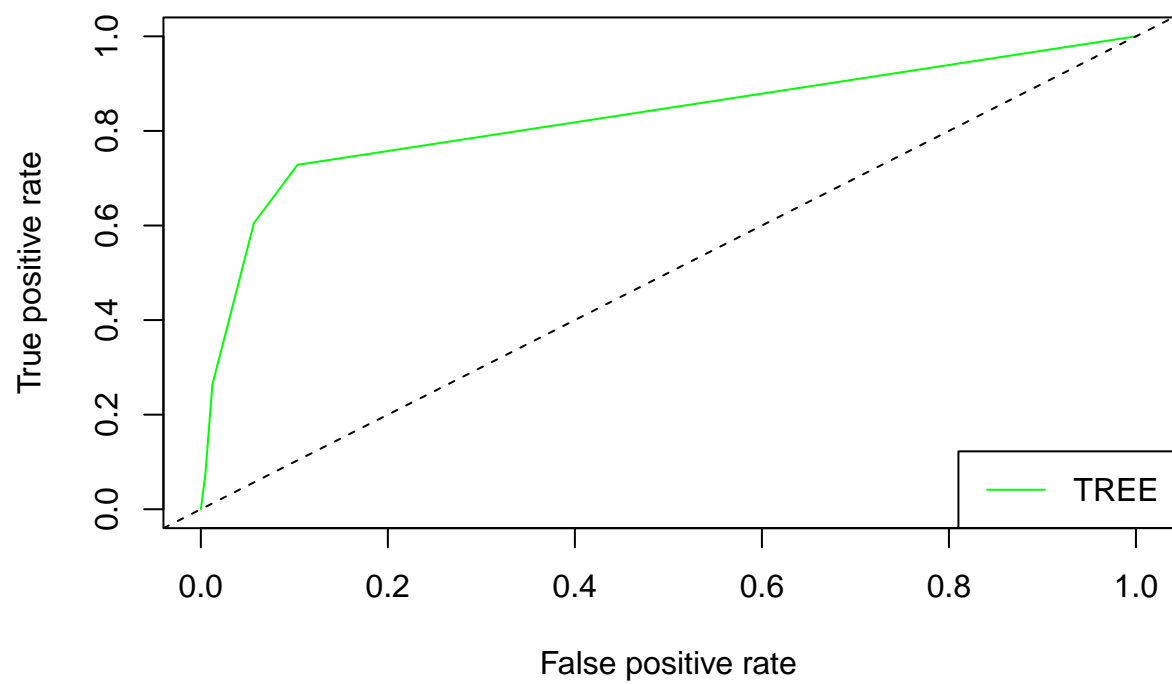
```r
plot(pt3, col="green")
plot(pr3, col="red", add=TRUE)
plot(pg3, col="blue", add=TRUE)
abline(0,1,lty=2)
legend("bottomright", c("TREE", "RANDOM FOREST", "GRADIENT BOOSTING"), col=c("green", "red", "blue"), b
```
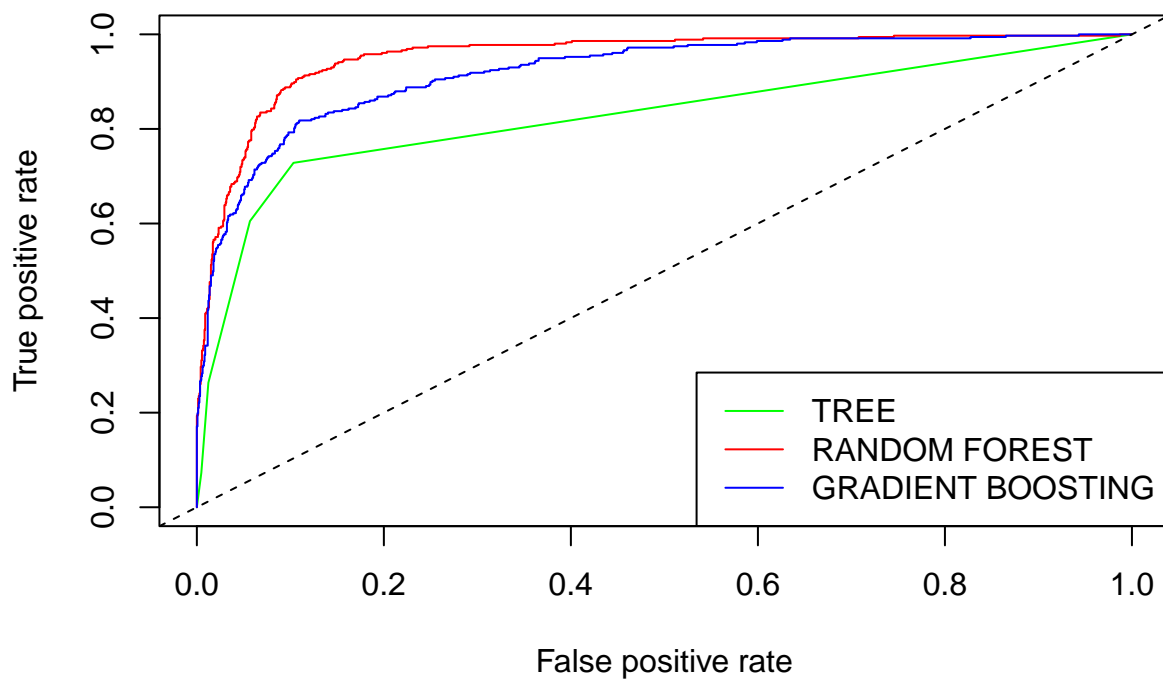
```
aucT = performance(pt2, "auc")@y.values
aucR = performance(pr2, "auc")@y.values
aucG = performance(pg2, "auc")@y.values
```

```
print(paste("TREE AUC=",aucT))
```

```
## [1] "TREE AUC= 0.826618121581281"
```

```
print(paste("RF AUC",aucR))
```

```
## [1] "RF AUC 0.953436405362943"
```

```
print(paste("GB AUC",aucG))
```

```
## [1] "GB AUC 0.920521802150007"
```

```
aucT = performance(pt2, "auc")@y.values
aucR = performance(pr2, "auc")@y.values
aucG = performance(pg2, "auc")@y.values
```

```
print(paste("TREE AUC=",aucT))
```

```
## [1] "TREE AUC= 0.826618121581281"
```

```r
print(paste("RF AUC",aucR))
```

```
## [1] "RF AUC 0.953436405362943"
```

```r
print(paste("GB AUC",aucG))
```

```
## [1] "GB AUC 0.920521802150007"
```

The ROC curves for all trees are optimal According to the results of my code Random Forest is slightly better than gradient boosting

```r
data_amt=data
data_amt$TARGET_BAD_FLAG = NULL
head(data_amt)
```

Step-3

```
##   TARGET_LOSS_AMT LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE IMP_YOJ M_YOJ
## 1             641 1100       25860         0     39025       0    10.5     0
## 2            1109 1300       70053         0     68400       0     7.0     0
## 3             767 1500       13500         0     16700       0     4.0     0
## 4            1425 1500       65000         1     89000       1     7.0     1
## 5               0 1700       97800         0    112000       0     3.0     0
## 6             335 1700       30548         0     40320       0     9.0     0
##   IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE IMP_NINQ M_NINQ
## 1         0       0          0        0  94.36667       0        1      0
## 2         0       0          2        0 121.83333       0        0      0
## 3         0       0          0        0 149.46667       0        1      0
## 4         1       1          1        1 174.00000       1        1      1
## 5         0       0          0        0  93.33333       0        0      0
## 6         0       0          0        0 101.46600       0        1      0
##   IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr FLAG.Job.Office
## 1        9      0    35.00000         1            0               0
## 2       14      0    35.00000         1            0               0
## 3       10      0    35.00000         1            0               0
## 4       20      1    35.00000         1            0               0
## 5       14      0    35.00000         1            0               1
## 6        8      0    37.11361         0            0               0
##   FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1              1                0              0             0
## 2              1                0              0             0
## 3              1                0              0             0
## 4              0                0              0             0
## 5              0                0              0             0
## 6              1                0              0             0
##   FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
## 2                   0                   1
## 3                   0                   1
```

```
## 4                    0                    0
## 5                    0                    1
## 6                    0                    1
```

```r
FLAG=sample(c(TRUE,FALSE), nrow(data_amt), replace=TRUE, prob=c(0.7,0.3))
data_train_s3=data_amt[FLAG, ]
data_test_s3=data_amt[! FLAG, ]
```

```r
mean(data_amt$TARGET_LOSS_AMT)
```

```
## [1] 2676.163
```

```r
mean(data_train_s3$TARGET_LOSS_AMT)
```

```
## [1] 2676.01
```

```r
mean(data_test_s3$TARGET_LOSS_AMT)
```

```
## [1] 2676.519
```

```r
dim(data_amt)
```

```
## [1] 5960    28
```

```r
dim(data_train_s3)
```

```
## [1] 4168    28
```

```r
dim(data_test_s3)
```

```
## [1] 1792    28
```

```r
T1A=rpart(data=data_train_s3, TARGET_LOSS_AMT~., control=tr_set, method="anova")
rpart.plot(T1A)
```
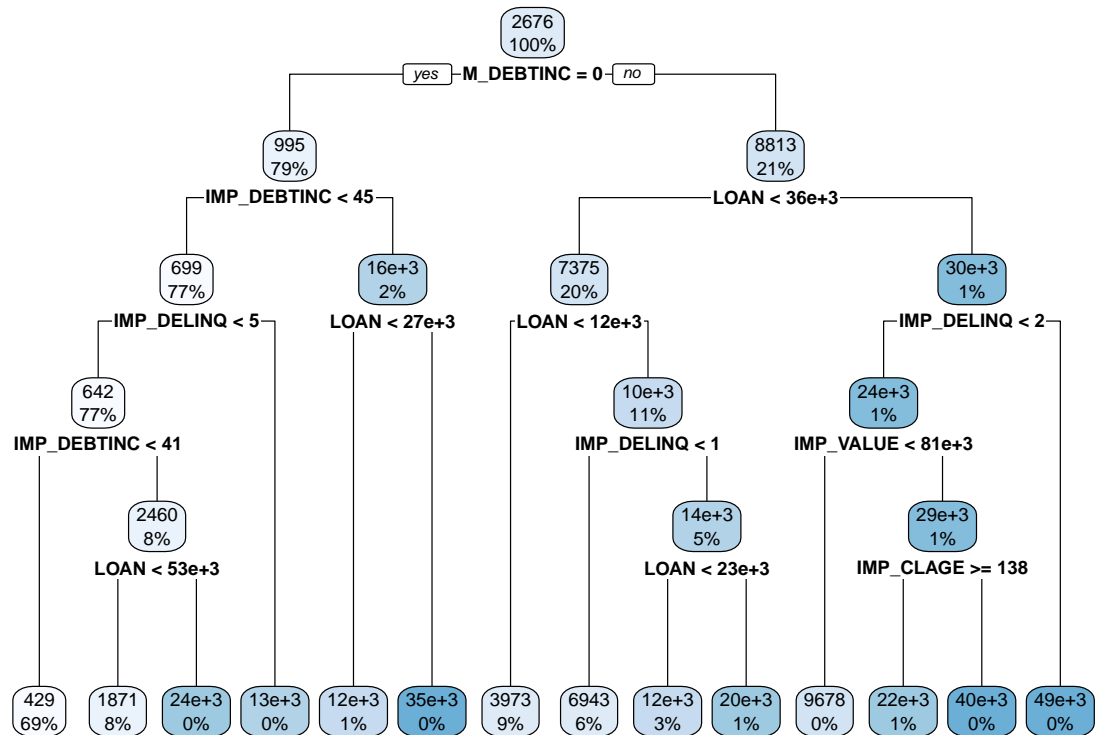
Decision Tree

```
T1A$variable.importance
```

```
##              LOAN        M_DEBTINC     IMP_DEBTINC       IMP_DELINQ
##       49690664826      42985254519     15939584553      15400438974
##         IMP_VALUE       IMP_MORTDUE       IMP_DEROG        IMP_CLAGE
##        9271157466       4145647445      3634659036       3469029852
##          IMP_CLNO FLAG.Reason.HomeImp FLAG.Reason.DebtCon        M_VALUE
##        3174251359       2820521327      2148907741       1958672130
##           M_DEROG          M_DELINQ          M_NINQ        M_MORTDUE
##        1889394893       1161439258       916925730        847333397
##             M_YOJ     FLAG.Job.Self         IMP_YOJ
##         585657276        452877917       390438184
```

```
rf_model_s3 = randomForest(data = data_train_s3, TARGET_LOSS_AMT ~., ntree=500, importance= TRUE)
importance(rf_model_s3)
```

RF

```
##                   %IncMSE IncNodePurity
## LOAN            60.668132   46695625794
## IMP_MORTDUE     17.146165   10494379059
## M_MORTDUE        5.153892     747061976
```

```
## IMP_VALUE           18.735447    13778814510
## M_VALUE             28.190389     3749783439
## IMP_YOJ             15.606857     8223538954
## M_YOJ                8.348570      683350163
## IMP_DEROG           21.995255     5774511085
## M_DEROG              8.842225     1258662250
## IMP_DELINQ          42.033453    20407610426
## M_DELINQ             6.506493      536619144
## IMP_CLAGE           25.161710    13446209097
## M_CLAGE              7.670149      257964369
## IMP_NINQ            17.389315     5663088617
## M_NINQ               4.939194      354225193
## IMP_CLNO            24.784895    11960859784
## M_CLNO              11.163432      234115096
## IMP_DEBTINC         28.439878    23417631709
## M_DEBTINC           40.538449    32416365766
## FLAG.Job.Mgr         9.203716     1052569539
## FLAG.Job.Office      7.495568     1046994234
## FLAG.Job.Other      10.543253     1280275312
## FLAG.Job.ProfExe     6.506114      912898185
## FLAG.Job.Sales      13.315858      827523754
## FLAG.Job.Self        4.561926     1376867544
## FLAG.Reason.DebtCon  8.337061     1592444846
## FLAG.Reason.HomeImp  7.951433     1409168007
```

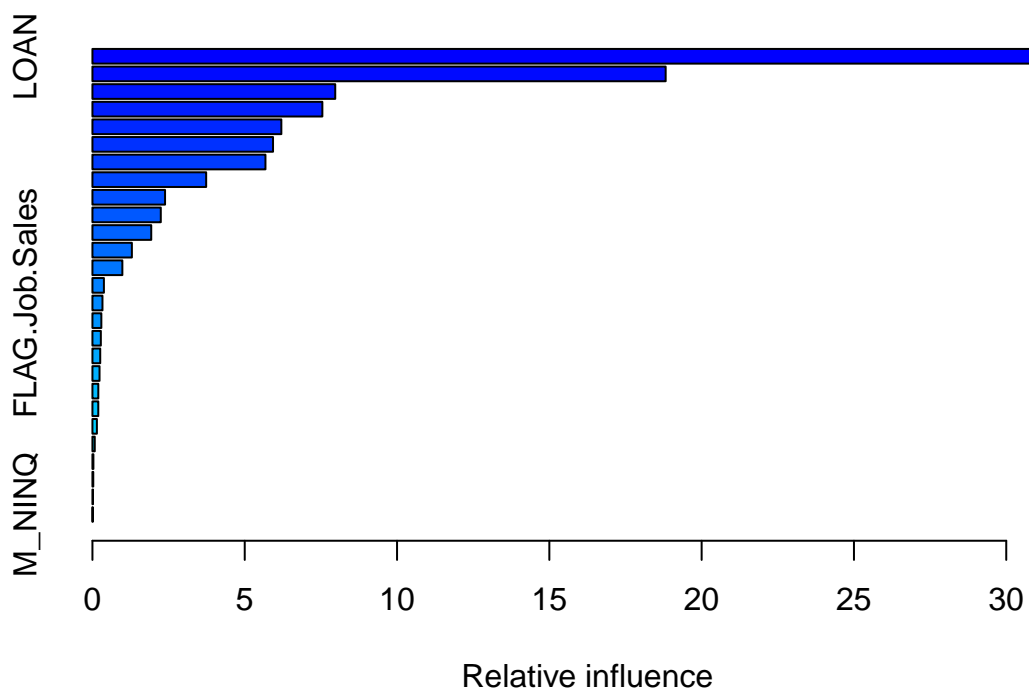```
varImpPlot(rf_model_s3)
```

## rf_model_s3
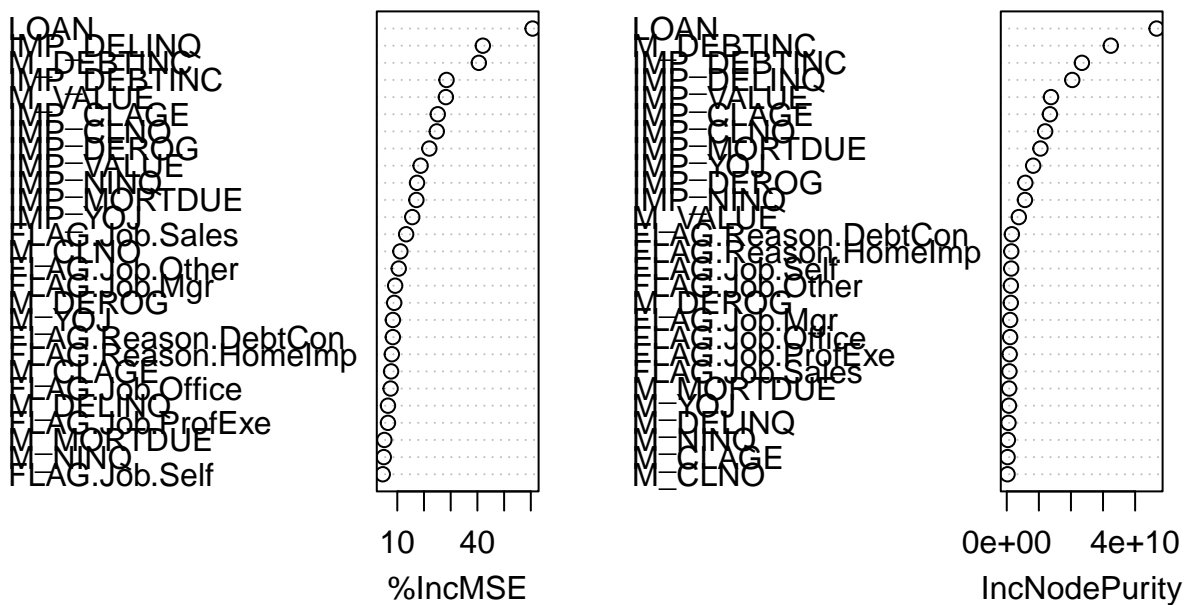
```
gb_model_s3 <- gbm(TARGET_LOSS_AMT ~ ., data = data_train_s3, n.trees = 1000, interaction.depth = 3)
```

GB

```
## Distribution not specified, assuming gaussian ...
```

```
summary(gb_model_s3)
```



```
##                              var     rel.inf
## LOAN                        LOAN  32.82671933
## M_DEBTINC              M_DEBTINC  18.81892143
## IMP_DEBTINC          IMP_DEBTINC   7.97112415
## IMP_DELINQ            IMP_DELINQ   7.54815288
## IMP_VALUE              IMP_VALUE   6.20169975
## IMP_CLNO                IMP_CLNO   5.92826943
## IMP_CLAGE              IMP_CLAGE   5.68031554
## IMP_MORTDUE          IMP_MORTDUE   3.73388190
## IMP_YOJ                  IMP_YOJ   2.38355360
## IMP_DEROG              IMP_DEROG   2.24347890
## IMP_NINQ                IMP_NINQ   1.93043719
## M_VALUE                  M_VALUE   1.29441644
## FLAG.Job.Self      FLAG.Job.Self   0.98207896
## M_DEROG                  M_DEROG   0.37683682
```

```
## FLAG.Job.Sales          FLAG.Job.Sales   0.32911830
## FLAG.Job.Other          FLAG.Job.Other   0.29211010
## FLAG.Job.Mgr              FLAG.Job.Mgr   0.27564298
## FLAG.Reason.DebtCon FLAG.Reason.DebtCon  0.25568173
## FLAG.Reason.HomeImp FLAG.Reason.HomeImp  0.23288681
## M_CLNO                          M_CLNO   0.19291864
## FLAG.Job.Office          FLAG.Job.Office  0.19212856
## FLAG.Job.ProfExe        FLAG.Job.ProfExe  0.14618191
## M_DELINQ                      M_DELINQ   0.07627523
## M_CLAGE                        M_CLAGE   0.03143796
## M_YOJ                            M_YOJ   0.02690461
## M_MORTDUE                    M_MORTDUE   0.01860585
## M_NINQ                          M_NINQ   0.01022101
```

```r
pred_tree <- predict(T1A, data_amt = data_test_s3)
pred_rf <- predict(rf_model_s3, data_amt = data_test_s3)
predictions_gb <- predict(gb_model_s3, data_amt = data_test_s3, n.trees = 500, type = "response")
```

```r
rmse_tree <- sqrt(mean((data_test_s3$TARGET_LOSS_AMT - pred_tree)^2))
```

```
## Warning in data_test_s3$TARGET_LOSS_AMT - pred_tree: longer object length is
## not a multiple of shorter object length
```

```r
rmse_rf <- sqrt(mean((data_test_s3$TARGET_LOSS_AMT - pred_rf)^2))
```

```
## Warning in data_test_s3$TARGET_LOSS_AMT - pred_rf: longer object length is not
## a multiple of shorter object length
```

```r
rmse_gb <- sqrt(mean((data_test_s3$TARGET_LOSS_AMT - predictions_gb)^2))
```

```
## Warning in data_test_s3$TARGET_LOSS_AMT - predictions_gb: longer object length
## is not a multiple of shorter object length
```

```r
print(paste("RMSE Decision Tree:", rmse_tree))
```

```
## [1] "RMSE Decision Tree: 8783.96757746315"
```

```r
print(paste("RMSE Random Forest:", rmse_rf))
```

```
## [1] "RMSE Random Forest: 8452.5466689552"
```

```r
print(paste("RMSE Gradient Boosting:", predictions_gb))
```

```
##    [1] "RMSE Gradient Boosting: 1813.61882430592"
##    [2] "RMSE Gradient Boosting: 210.482190398147"
##    [3] "RMSE Gradient Boosting: 1205.8195522931"
##    [4] "RMSE Gradient Boosting: -1007.35563524261"
##    [5] "RMSE Gradient Boosting: 4652.07154131224"
##    [6] "RMSE Gradient Boosting: 3030.74294766691"
```

```
##     [7]  "RMSE Gradient Boosting: 2224.29367979569"
##     [8]  "RMSE Gradient Boosting: 5410.60757080469"
##     [9]  "RMSE Gradient Boosting: 997.239804687957"
##    [10]  "RMSE Gradient Boosting: 2056.89271710568"
##    [11]  "RMSE Gradient Boosting: 2005.23254576591"
##    [12]  "RMSE Gradient Boosting: 2606.89529471987"
##    [13]  "RMSE Gradient Boosting: 769.289703625703"
##    [14]  "RMSE Gradient Boosting: 3219.46172939439"
##    [15]  "RMSE Gradient Boosting: -1412.56730114544"
##    [16]  "RMSE Gradient Boosting: 3729.66703325554"
##    [17]  "RMSE Gradient Boosting: 1911.08466841181"
##    [18]  "RMSE Gradient Boosting: 3767.01305600724"
##    [19]  "RMSE Gradient Boosting: 3158.39494980792"
##    [20]  "RMSE Gradient Boosting: -1550.07799874861"
##    [21]  "RMSE Gradient Boosting: 1988.38878248125"
##    [22]  "RMSE Gradient Boosting: 550.136440198496"
##    [23]  "RMSE Gradient Boosting: 4225.61705104918"
##    [24]  "RMSE Gradient Boosting: 2314.99411972693"
##    [25]  "RMSE Gradient Boosting: -1395.20636574849"
##    [26]  "RMSE Gradient Boosting: 761.095543757456"
##    [27]  "RMSE Gradient Boosting: 5899.54175538347"
##    [28]  "RMSE Gradient Boosting: -1412.56730114544"
##    [29]  "RMSE Gradient Boosting: 4409.44687220316"
##    [30]  "RMSE Gradient Boosting: 2841.21936614526"
##    [31]  "RMSE Gradient Boosting: 3398.73172040665"
##    [32]  "RMSE Gradient Boosting: 1404.8039931736"
##    [33]  "RMSE Gradient Boosting: 1314.97893447699"
##    [34]  "RMSE Gradient Boosting: 2380.17052771317"
##    [35]  "RMSE Gradient Boosting: 2024.16905594919"
##    [36]  "RMSE Gradient Boosting: 3835.76832631366"
##    [37]  "RMSE Gradient Boosting: 1014.73257160335"
##    [38]  "RMSE Gradient Boosting: 1748.78049665504"
##    [39]  "RMSE Gradient Boosting: 2046.7568431536"
##    [40]  "RMSE Gradient Boosting: 4425.43852678652"
##    [41]  "RMSE Gradient Boosting: -1747.39756056143"
##    [42]  "RMSE Gradient Boosting: 1706.31858765579"
##    [43]  "RMSE Gradient Boosting: 1441.45851973409"
##    [44]  "RMSE Gradient Boosting: 1743.1118411104"
##    [45]  "RMSE Gradient Boosting: 1256.11643081747"
##    [46]  "RMSE Gradient Boosting: 2024.52952506791"
##    [47]  "RMSE Gradient Boosting: -1244.25875891837"
##    [48]  "RMSE Gradient Boosting: 6175.17075707722"
##    [49]  "RMSE Gradient Boosting: 7391.40624861555"
##    [50]  "RMSE Gradient Boosting: -1367.29723966664"
##    [51]  "RMSE Gradient Boosting: -1232.47751090683"
##    [52]  "RMSE Gradient Boosting: -1114.4568394849"
##    [53]  "RMSE Gradient Boosting: -1405.51674783229"
##    [54]  "RMSE Gradient Boosting: -1561.76097563909"
##    [55]  "RMSE Gradient Boosting: -895.750456001597"
##    [56]  "RMSE Gradient Boosting: 4584.70177380575"
##    [57]  "RMSE Gradient Boosting: 2633.91940813126"
##    [58]  "RMSE Gradient Boosting: 3114.34608068203"
##    [59]  "RMSE Gradient Boosting: 2785.9093247001"
##    [60]  "RMSE Gradient Boosting: 3049.36450053445"
```

```
##   [61] "RMSE Gradient Boosting: 1406.03545076606"
##   [62] "RMSE Gradient Boosting: 1992.42659048766"
##   [63] "RMSE Gradient Boosting: 3966.11966101793"
##   [64] "RMSE Gradient Boosting: 3298.11463703247"
##   [65] "RMSE Gradient Boosting: -2280.49163049648"
##   [66] "RMSE Gradient Boosting: -1564.32189901142"
##   [67] "RMSE Gradient Boosting: -1083.68963734297"
##   [68] "RMSE Gradient Boosting: 4856.06983734832"
##   [69] "RMSE Gradient Boosting: 2065.08237362759"
##   [70] "RMSE Gradient Boosting: -1803.94240969847"
##   [71] "RMSE Gradient Boosting: 3138.28722355165"
##   [72] "RMSE Gradient Boosting: 1728.59582895297"
##   [73] "RMSE Gradient Boosting: -1626.50332292669"
##   [74] "RMSE Gradient Boosting: 763.360073801186"
##   [75] "RMSE Gradient Boosting: 822.708927115468"
##   [76] "RMSE Gradient Boosting: -351.013975576953"
##   [77] "RMSE Gradient Boosting: 2231.29481963251"
##   [78] "RMSE Gradient Boosting: -513.09832597152"
##   [79] "RMSE Gradient Boosting: -1518.84196721702"
##   [80] "RMSE Gradient Boosting: 3450.78723111153"
##   [81] "RMSE Gradient Boosting: 4273.14928782822"
##   [82] "RMSE Gradient Boosting: 2048.518857262"
##   [83] "RMSE Gradient Boosting: 2896.31553119952"
##   [84] "RMSE Gradient Boosting: 5087.62488843105"
##   [85] "RMSE Gradient Boosting: -899.615993031056"
##   [86] "RMSE Gradient Boosting: -654.526618991916"
##   [87] "RMSE Gradient Boosting: -1324.12054377742"
##   [88] "RMSE Gradient Boosting: 3718.5347046622"
##   [89] "RMSE Gradient Boosting: 357.876630554202"
##   [90] "RMSE Gradient Boosting: -1871.02007140349"
##   [91] "RMSE Gradient Boosting: -755.66196970259"
##   [92] "RMSE Gradient Boosting: -223.973199680005"
##   [93] "RMSE Gradient Boosting: 2180.19641736011"
##   [94] "RMSE Gradient Boosting: 4108.8110795962"
##   [95] "RMSE Gradient Boosting: 860.534936240934"
##   [96] "RMSE Gradient Boosting: 2069.97348104931"
##   [97] "RMSE Gradient Boosting: -1236.20803298701"
##   [98] "RMSE Gradient Boosting: -920.947978911263"
##   [99] "RMSE Gradient Boosting: 1961.32155753784"
##  [100] "RMSE Gradient Boosting: 3505.29892863497"
##  [101] "RMSE Gradient Boosting: 1911.84615940617"
##  [102] "RMSE Gradient Boosting: 2778.82344471044"
##  [103] "RMSE Gradient Boosting: 2112.05151263469"
##  [104] "RMSE Gradient Boosting: 3508.61432796503"
##  [105] "RMSE Gradient Boosting: 945.68564048076"
##  [106] "RMSE Gradient Boosting: 1552.3981627118"
##  [107] "RMSE Gradient Boosting: 2460.4767290144"
##  [108] "RMSE Gradient Boosting: 3186.28600142905"
##  [109] "RMSE Gradient Boosting: 2705.7368913908"
##  [110] "RMSE Gradient Boosting: 2633.32749859054"
##  [111] "RMSE Gradient Boosting: 1975.22818695388"
##  [112] "RMSE Gradient Boosting: 1013.68499981829"
##  [113] "RMSE Gradient Boosting: 277.851435461903"
##  [114] "RMSE Gradient Boosting: 1146.45175235514"
```

```
## [115] "RMSE Gradient Boosting: 2709.56485767756"
## [116] "RMSE Gradient Boosting: 871.670254880626"
## [117] "RMSE Gradient Boosting: 2828.34380902718"
## [118] "RMSE Gradient Boosting: 3378.76187229686"
## [119] "RMSE Gradient Boosting: 3575.18410749409"
## [120] "RMSE Gradient Boosting: 833.142799862349"
## [121] "RMSE Gradient Boosting: 2536.20241647643"
## [122] "RMSE Gradient Boosting: 7733.37096156266"
## [123] "RMSE Gradient Boosting: 2285.41676498799"
## [124] "RMSE Gradient Boosting: 6496.03611464975"
## [125] "RMSE Gradient Boosting: 2167.40035259686"
## [126] "RMSE Gradient Boosting: -926.246850155808"
## [127] "RMSE Gradient Boosting: 5080.05588344755"
## [128] "RMSE Gradient Boosting: -798.235695938045"
## [129] "RMSE Gradient Boosting: -218.206754431684"
## [130] "RMSE Gradient Boosting: -1145.46018880613"
## [131] "RMSE Gradient Boosting: -743.694580406623"
## [132] "RMSE Gradient Boosting: 3341.93486489653"
## [133] "RMSE Gradient Boosting: -736.783474269403"
## [134] "RMSE Gradient Boosting: -899.003397619739"
## [135] "RMSE Gradient Boosting: -894.21008861668"
## [136] "RMSE Gradient Boosting: 2465.80153168048"
## [137] "RMSE Gradient Boosting: 4498.83262168613"
## [138] "RMSE Gradient Boosting: 1898.71441221766"
## [139] "RMSE Gradient Boosting: -510.111678728154"
## [140] "RMSE Gradient Boosting: -295.310863668009"
## [141] "RMSE Gradient Boosting: 3602.48251972462"
## [142] "RMSE Gradient Boosting: -1963.12623137818"
## [143] "RMSE Gradient Boosting: 3663.71312082193"
## [144] "RMSE Gradient Boosting: 4258.68488454079"
## [145] "RMSE Gradient Boosting: 5381.24714039853"
## [146] "RMSE Gradient Boosting: -330.644371089498"
## [147] "RMSE Gradient Boosting: -943.373395242124"
## [148] "RMSE Gradient Boosting: -963.087081618717"
## [149] "RMSE Gradient Boosting: -1832.48849193756"
## [150] "RMSE Gradient Boosting: 3189.74439578488"
## [151] "RMSE Gradient Boosting: -379.473939287529"
## [152] "RMSE Gradient Boosting: -646.585424081399"
## [153] "RMSE Gradient Boosting: -1607.10604114722"
## [154] "RMSE Gradient Boosting: -597.996507509873"
## [155] "RMSE Gradient Boosting: -737.834585019899"
## [156] "RMSE Gradient Boosting: -651.94056999415"
## [157] "RMSE Gradient Boosting: -723.858172614605"
## [158] "RMSE Gradient Boosting: 253.949458151676"
## [159] "RMSE Gradient Boosting: -1825.74178328855"
## [160] "RMSE Gradient Boosting: 3598.04280072559"
## [161] "RMSE Gradient Boosting: 2455.11828189602"
## [162] "RMSE Gradient Boosting: -559.091921557568"
## [163] "RMSE Gradient Boosting: -1145.65448417029"
## [164] "RMSE Gradient Boosting: 334.584755905873"
## [165] "RMSE Gradient Boosting: -711.159585665589"
## [166] "RMSE Gradient Boosting: 223.844249135647"
## [167] "RMSE Gradient Boosting: 5981.29430861835"
## [168] "RMSE Gradient Boosting: 3427.81645124741"
```

```
## [169] "RMSE Gradient Boosting: 2574.3807152896"
## [170] "RMSE Gradient Boosting: 3090.57291012495"
## [171] "RMSE Gradient Boosting: -1148.18039540966"
## [172] "RMSE Gradient Boosting: -1081.24439586877"
## [173] "RMSE Gradient Boosting: -75.7136520136923"
## [174] "RMSE Gradient Boosting: 31.0021922847613"
## [175] "RMSE Gradient Boosting: 604.950011710993"
## [176] "RMSE Gradient Boosting: -670.932694009394"
## [177] "RMSE Gradient Boosting: -496.926487757121"
## [178] "RMSE Gradient Boosting: -127.480920624212"
## [179] "RMSE Gradient Boosting: 2174.60420266416"
## [180] "RMSE Gradient Boosting: 3747.95554423404"
## [181] "RMSE Gradient Boosting: -1811.00329894468"
## [182] "RMSE Gradient Boosting: -712.059875126638"
## [183] "RMSE Gradient Boosting: -529.204193993192"
## [184] "RMSE Gradient Boosting: -559.091921557568"
## [185] "RMSE Gradient Boosting: -347.366775496519"
## [186] "RMSE Gradient Boosting: 18.8894070318177"
## [187] "RMSE Gradient Boosting: 1880.26615725286"
## [188] "RMSE Gradient Boosting: 466.096195313982"
## [189] "RMSE Gradient Boosting: 321.033920007961"
## [190] "RMSE Gradient Boosting: -325.035500376667"
## [191] "RMSE Gradient Boosting: 857.229538421221"
## [192] "RMSE Gradient Boosting: -559.091921557568"
## [193] "RMSE Gradient Boosting: 194.214254667625"
## [194] "RMSE Gradient Boosting: -876.477437638999"
## [195] "RMSE Gradient Boosting: -232.372822813371"
## [196] "RMSE Gradient Boosting: 1866.67136627364"
## [197] "RMSE Gradient Boosting: -763.483763411547"
## [198] "RMSE Gradient Boosting: 133.19830926611"
## [199] "RMSE Gradient Boosting: 6004.77961464363"
## [200] "RMSE Gradient Boosting: 221.272072115273"
## [201] "RMSE Gradient Boosting: 809.550992898995"
## [202] "RMSE Gradient Boosting: -820.014045246666"
## [203] "RMSE Gradient Boosting: 310.287105393848"
## [204] "RMSE Gradient Boosting: -559.091921557568"
## [205] "RMSE Gradient Boosting: 11103.868753078"
## [206] "RMSE Gradient Boosting: -559.091921557568"
## [207] "RMSE Gradient Boosting: 5525.1146499395"
## [208] "RMSE Gradient Boosting: 6430.51714908638"
## [209] "RMSE Gradient Boosting: 5349.63603934439"
## [210] "RMSE Gradient Boosting: 7444.10084232403"
## [211] "RMSE Gradient Boosting: 3408.42668114257"
## [212] "RMSE Gradient Boosting: 5570.52045696304"
## [213] "RMSE Gradient Boosting: 3238.16449174737"
## [214] "RMSE Gradient Boosting: 3671.97388156176"
## [215] "RMSE Gradient Boosting: 4535.3644209575"
## [216] "RMSE Gradient Boosting: 1910.24852298773"
## [217] "RMSE Gradient Boosting: 2677.63881554465"
## [218] "RMSE Gradient Boosting: 5116.10944686536"
## [219] "RMSE Gradient Boosting: 3650.92686982029"
## [220] "RMSE Gradient Boosting: 1309.16350816802"
## [221] "RMSE Gradient Boosting: 4760.11860763923"
## [222] "RMSE Gradient Boosting: 8140.9526220442"
```

```
## [223] "RMSE Gradient Boosting: 4281.71402253836"
## [224] "RMSE Gradient Boosting: -481.324864268618"
## [225] "RMSE Gradient Boosting: -963.087081618717"
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## [4011] "RMSE Gradient Boosting: -87.1330296929174"
## [4012] "RMSE Gradient Boosting: 13084.0892731788"
## [4013] "RMSE Gradient Boosting: -850.557693501001"
## [4014] "RMSE Gradient Boosting: 1461.0825852598"
## [4015] "RMSE Gradient Boosting: 3043.39870959481"
## [4016] "RMSE Gradient Boosting: 2979.03389011004"
## [4017] "RMSE Gradient Boosting: 11258.7084085057"
## [4018] "RMSE Gradient Boosting: 1054.64571672183"
## [4019] "RMSE Gradient Boosting: -650.526166716008"
## [4020] "RMSE Gradient Boosting: -510.501527987398"
## [4021] "RMSE Gradient Boosting: 627.273677394833"
## [4022] "RMSE Gradient Boosting: 1102.78814186049"
## [4023] "RMSE Gradient Boosting: 45401.3731192114"
## [4024] "RMSE Gradient Boosting: 31062.9667928204"
## [4025] "RMSE Gradient Boosting: 12764.6714742376"
## [4026] "RMSE Gradient Boosting: 4830.15880614788"
## [4027] "RMSE Gradient Boosting: 4685.15798539251"
## [4028] "RMSE Gradient Boosting: 38025.5846894389"
## [4029] "RMSE Gradient Boosting: -241.728052197259"
## [4030] "RMSE Gradient Boosting: 8366.26379299701"
## [4031] "RMSE Gradient Boosting: 16869.0843761366"
## [4032] "RMSE Gradient Boosting: -1275.9115562002"
## [4033] "RMSE Gradient Boosting: 1878.76268728796"
## [4034] "RMSE Gradient Boosting: 52641.4686611039"
## [4035] "RMSE Gradient Boosting: 40413.3208674652"
## [4036] "RMSE Gradient Boosting: -2102.47149439986"
## [4037] "RMSE Gradient Boosting: 232.394704660469"
## [4038] "RMSE Gradient Boosting: 19248.2984870293"
## [4039] "RMSE Gradient Boosting: 2448.16989937071"
## [4040] "RMSE Gradient Boosting: -2131.50614341376"
## [4041] "RMSE Gradient Boosting: -1761.71684542798"
## [4042] "RMSE Gradient Boosting: 24441.4106127785"
## [4043] "RMSE Gradient Boosting: 30061.0337028415"
## [4044] "RMSE Gradient Boosting: 617.526681229657"
## [4045] "RMSE Gradient Boosting: 4842.75139991229"
## [4046] "RMSE Gradient Boosting: -2389.00609420706"
## [4047] "RMSE Gradient Boosting: -429.590139308618"
## [4048] "RMSE Gradient Boosting: 886.874225844055"
## [4049] "RMSE Gradient Boosting: -1252.59824860501"
## [4050] "RMSE Gradient Boosting: 39704.1022874542"
## [4051] "RMSE Gradient Boosting: 272.770212796882"
## [4052] "RMSE Gradient Boosting: 2097.61089574301"
## [4053] "RMSE Gradient Boosting: -613.950545303905"
## [4054] "RMSE Gradient Boosting: 4181.57456771992"
## [4055] "RMSE Gradient Boosting: 2396.82337213943"
## [4056] "RMSE Gradient Boosting: -921.602566267731"
```

```
## [4057] "RMSE Gradient Boosting: 3546.94801458612"
## [4058] "RMSE Gradient Boosting: 2103.72850695335"
## [4059] "RMSE Gradient Boosting: -1973.27399121522"
## [4060] "RMSE Gradient Boosting: 41127.5017096166"
## [4061] "RMSE Gradient Boosting: 47090.1113156567"
## [4062] "RMSE Gradient Boosting: 41952.5443450767"
## [4063] "RMSE Gradient Boosting: 48678.0445464367"
## [4064] "RMSE Gradient Boosting: 16388.3816346685"
## [4065] "RMSE Gradient Boosting: 15424.5936875006"
## [4066] "RMSE Gradient Boosting: 56123.1507538724"
## [4067] "RMSE Gradient Boosting: 28380.4593402609"
## [4068] "RMSE Gradient Boosting: 49481.0941038575"
## [4069] "RMSE Gradient Boosting: 48706.8664101906"
## [4070] "RMSE Gradient Boosting: 47421.3073727333"
## [4071] "RMSE Gradient Boosting: -468.060068289087"
## [4072] "RMSE Gradient Boosting: 1655.64005638033"
## [4073] "RMSE Gradient Boosting: 29551.5622346655"
## [4074] "RMSE Gradient Boosting: 10696.1605945606"
## [4075] "RMSE Gradient Boosting: 22555.6134262944"
## [4076] "RMSE Gradient Boosting: -1451.48808440882"
## [4077] "RMSE Gradient Boosting: 51480.7578952562"
## [4078] "RMSE Gradient Boosting: -1196.03951305605"
## [4079] "RMSE Gradient Boosting: 1807.20591118575"
## [4080] "RMSE Gradient Boosting: -1982.80557115739"
## [4081] "RMSE Gradient Boosting: 16324.0874224276"
## [4082] "RMSE Gradient Boosting: -1140.34536976234"
## [4083] "RMSE Gradient Boosting: -890.091387566087"
## [4084] "RMSE Gradient Boosting: 325.846647604689"
## [4085] "RMSE Gradient Boosting: -1673.48148673459"
## [4086] "RMSE Gradient Boosting: -1365.8612029454"
## [4087] "RMSE Gradient Boosting: -2247.25794667332"
## [4088] "RMSE Gradient Boosting: -907.020872104368"
## [4089] "RMSE Gradient Boosting: 8069.45574146655"
## [4090] "RMSE Gradient Boosting: -875.806639182997"
## [4091] "RMSE Gradient Boosting: -2344.45184159456"
## [4092] "RMSE Gradient Boosting: 1076.06209619238"
## [4093] "RMSE Gradient Boosting: -406.175718157078"
## [4094] "RMSE Gradient Boosting: -987.478547411278"
## [4095] "RMSE Gradient Boosting: 934.475374175762"
## [4096] "RMSE Gradient Boosting: 240.365767885143"
## [4097] "RMSE Gradient Boosting: -608.721747838417"
## [4098] "RMSE Gradient Boosting: -346.207684209653"
## [4099] "RMSE Gradient Boosting: -1114.59527967596"
## [4100] "RMSE Gradient Boosting: -55.0626932122643"
## [4101] "RMSE Gradient Boosting: 457.549145894649"
## [4102] "RMSE Gradient Boosting: 20.3167365798017"
## [4103] "RMSE Gradient Boosting: -853.733184355765"
## [4104] "RMSE Gradient Boosting: 297.000622879239"
## [4105] "RMSE Gradient Boosting: 3374.81513613868"
## [4106] "RMSE Gradient Boosting: -825.255280245622"
## [4107] "RMSE Gradient Boosting: 334.403262743169"
## [4108] "RMSE Gradient Boosting: 22673.296827913"
## [4109] "RMSE Gradient Boosting: 2559.15283165512"
## [4110] "RMSE Gradient Boosting: 42021.6322765372"
```

```
## [4111] "RMSE Gradient Boosting: 3006.43045064061"
## [4112] "RMSE Gradient Boosting: 1570.81396794116"
## [4113] "RMSE Gradient Boosting: 39455.8004798353"
## [4114] "RMSE Gradient Boosting: 6824.32195047666"
## [4115] "RMSE Gradient Boosting: 7053.35917707705"
## [4116] "RMSE Gradient Boosting: 45475.3006444631"
## [4117] "RMSE Gradient Boosting: 16067.4022743669"
## [4118] "RMSE Gradient Boosting: -1869.36724537469"
## [4119] "RMSE Gradient Boosting: -3283.1471603713"
## [4120] "RMSE Gradient Boosting: -1616.77513097951"
## [4121] "RMSE Gradient Boosting: 6582.99988302437"
## [4122] "RMSE Gradient Boosting: -3295.63222717185"
## [4123] "RMSE Gradient Boosting: -269.526678116834"
## [4124] "RMSE Gradient Boosting: 47179.5115446878"
## [4125] "RMSE Gradient Boosting: 2092.4339269125"
## [4126] "RMSE Gradient Boosting: 13947.798995289"
## [4127] "RMSE Gradient Boosting: -706.445511599026"
## [4128] "RMSE Gradient Boosting: 1092.82858419308"
## [4129] "RMSE Gradient Boosting: 6308.62786996372"
## [4130] "RMSE Gradient Boosting: -563.267700672308"
## [4131] "RMSE Gradient Boosting: -1085.10034405317"
## [4132] "RMSE Gradient Boosting: 4985.75588331985"
## [4133] "RMSE Gradient Boosting: 58770.2920276725"
## [4134] "RMSE Gradient Boosting: -1883.01070510895"
## [4135] "RMSE Gradient Boosting: 4308.72502656203"
## [4136] "RMSE Gradient Boosting: -2321.18150624724"
## [4137] "RMSE Gradient Boosting: 2172.30270856149"
## [4138] "RMSE Gradient Boosting: 1939.65304334845"
## [4139] "RMSE Gradient Boosting: 175.187414841444"
## [4140] "RMSE Gradient Boosting: 3228.0897317581"
## [4141] "RMSE Gradient Boosting: 3502.26367989279"
## [4142] "RMSE Gradient Boosting: 3088.39052926653"
## [4143] "RMSE Gradient Boosting: 54048.730194849"
## [4144] "RMSE Gradient Boosting: 54658.8324650973"
## [4145] "RMSE Gradient Boosting: 76088.1973028285"
## [4146] "RMSE Gradient Boosting: 55712.4490254459"
## [4147] "RMSE Gradient Boosting: 16426.3147310822"
## [4148] "RMSE Gradient Boosting: 569.071224025343"
## [4149] "RMSE Gradient Boosting: 1680.87496043854"
## [4150] "RMSE Gradient Boosting: 179.630639008482"
## [4151] "RMSE Gradient Boosting: 1277.01061332114"
## [4152] "RMSE Gradient Boosting: 885.145202899202"
## [4153] "RMSE Gradient Boosting: -1041.45800598527"
## [4154] "RMSE Gradient Boosting: -1294.99024296134"
## [4155] "RMSE Gradient Boosting: -2004.31813410492"
## [4156] "RMSE Gradient Boosting: -1283.79117331517"
## [4157] "RMSE Gradient Boosting: 1292.02301022017"
## [4158] "RMSE Gradient Boosting: 523.169496036976"
## [4159] "RMSE Gradient Boosting: -327.410986390127"
## [4160] "RMSE Gradient Boosting: 1307.86326536208"
## [4161] "RMSE Gradient Boosting: -1935.72705605079"
## [4162] "RMSE Gradient Boosting: 185.10842100155"
## [4163] "RMSE Gradient Boosting: 1844.93246422846"
## [4164] "RMSE Gradient Boosting: 265.386337985099"
```

```
## [4165] "RMSE Gradient Boosting: 88.4176962945912"
## [4166] "RMSE Gradient Boosting: 88.4176962945912"
## [4167] "RMSE Gradient Boosting: 185.10842100155"
## [4168] "RMSE Gradient Boosting: -453.993971400583"
```

The trees all are optimal According to the results of my code, both decision trees are better than Random Forest and Gradient Boosting

continue to week-6

```
SEED=1
set.seed(SEED)
```

```
data_flag= data
data_flag$TARGET_LOSS_AMT= NULL
head(data_flag)
```

LOGISTIC

```
##   TARGET_BAD_FLAG LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE IMP_YOJ M_YOJ
## 1               1 1100       25860         0     39025       0    10.5     0
## 2               1 1300       70053         0     68400       0     7.0     0
## 3               1 1500       13500         0     16700       0     4.0     0
## 4               1 1500       65000         1     89000       1     7.0     1
## 5               0 1700       97800         0    112000       0     3.0     0
## 6               1 1700       30548         0     40320       0     9.0     0
##   IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE IMP_NINQ M_NINQ
## 1         0       0          0        0  94.36667       0        1      0
## 2         0       0          2        0 121.83333       0        0      0
## 3         0       0          0        0 149.46667       0        1      0
## 4         1       1          1        1 174.00000       1        1      1
## 5         0       0          0        0  93.33333       0        0      0
## 6         0       0          0        0 101.46600       0        1      0
##   IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr FLAG.Job.Office
## 1        9      0    35.00000         1            0               0
## 2       14      0    35.00000         1            0               0
## 3       10      0    35.00000         1            0               0
## 4       20      1    35.00000         1            0               0
## 5       14      0    35.00000         1            0               1
## 6        8      0    37.11361         0            0               0
##   FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1              1                0              0             0
## 2              1                0              0             0
## 3              1                0              0             0
## 4              0                0              0             0
## 5              0                0              0             0
## 6              1                0              0             0
##   FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
```

```
## 2                         0                        1
## 3                         0                        1
## 4                         0                        0
## 5                         0                        1
## 6                         0                        1
```

```
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.7,0.3))
data_train= data_flag[FLAG, ]
data_test= data_flag[! FLAG, ]
```

```
dim(data_flag)
```

```
## [1] 5960    28
```

```
dim(data_train)
```

```
## [1] 4142    28
```

```
dim(data_test)
```

```
## [1] 1818    28
```

```
theUpper_LR = glm(TARGET_BAD_FLAG ~ ., family = "binomial", data=data_train)
theLower_LR = glm(TARGET_BAD_FLAG ~ 1, family = "binomial", data=data_train)
summary(theUpper_LR)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ ., family = "binomial", data = data_train)
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)      -6.817e+00  6.558e-01 -10.395  < 2e-16 ***
## LOAN             -8.996e-06  5.694e-06  -1.580 0.114122
## IMP_MORTDUE      -3.482e-06  2.092e-06  -1.664 0.096053 .
## M_MORTDUE         3.647e-01  2.491e-01   1.464 0.143231
## IMP_VALUE         4.356e-06  1.495e-06   2.914 0.003572 **
## M_VALUE           4.945e+00  6.167e-01   8.017 1.08e-15 ***
## IMP_YOJ          -2.010e-02  8.271e-03  -2.430 0.015103 *
## M_YOJ            -7.720e-01  2.427e-01  -3.181 0.001466 **
## IMP_DEROG         5.869e-01  7.617e-02   7.706 1.30e-14 ***
## M_DEROG          -2.655e+00  3.603e-01  -7.367 1.74e-13 ***
## IMP_DELINQ        8.182e-01  6.264e-02  13.062  < 2e-16 ***
## M_DELINQ         -1.101e+00  4.859e-01  -2.266 0.023465 *
## IMP_CLAGE        -5.466e-03  8.103e-04  -6.746 1.52e-11 ***
## M_CLAGE           9.834e-01  4.403e-01   2.233 0.025529 *
## IMP_NINQ          1.528e-01  3.175e-02   4.813 1.48e-06 ***
## M_NINQ           -2.494e-01  4.538e-01  -0.550 0.582542
## IMP_CLNO         -1.600e-02  6.331e-03  -2.527 0.011513 *
## M_CLNO            2.693e+00  7.552e-01   3.565 0.000363 ***
## IMP_DEBTINC       9.231e-02  1.017e-02   9.075  < 2e-16 ***
```

```
## M_DEBTINC          2.679e+00  1.144e-01  23.425  < 2e-16 ***
## FLAG.Job.Mgr        2.091e+00  4.989e-01   4.191 2.77e-05 ***
## FLAG.Job.Office     1.414e+00  5.005e-01   2.824 0.004736 **
## FLAG.Job.Other      2.081e+00  4.825e-01   4.314 1.60e-05 ***
## FLAG.Job.ProfExe    1.972e+00  4.965e-01   3.971 7.16e-05 ***
## FLAG.Job.Sales      3.240e+00  5.794e-01   5.592 2.24e-08 ***
## FLAG.Job.Self       2.518e+00  5.650e-01   4.456 8.34e-06 ***
## FLAG.Reason.DebtCon -1.318e-01  3.661e-01  -0.360 0.718960
## FLAG.Reason.HomeImp -5.659e-02  3.728e-01  -0.152 0.879329
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 2248.2  on 4114  degrees of freedom
## AIC: 2304.2
##
## Number of Fisher Scoring iterations: 6
```

```r
summary(theLower_LR)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ 1, family = "binomial", data = data_train)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.38087    0.03878  -35.61   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 4155.3  on 4141  degrees of freedom
## AIC: 4157.3
##
## Number of Fisher Scoring iterations: 4
```

```r
lr_model = stepAIC(theLower_LR, direction="backward", scope=list(lower=theLower_LR, upper=theUpper_LR))
```

```
## Start:  AIC=4157.3
## TARGET_BAD_FLAG ~ 1
```

```r
summary(lr_model)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ 1, family = "binomial", data = data_train)
##
## Coefficients:
```

```
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.38087    0.03878  -35.61   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 4155.3  on 4141  degrees of freedom
## AIC: 4157.3
##
## Number of Fisher Scoring iterations: 4
```

```r
plr = predict(lr_model, data_test, type="response")
plr2 = prediction(plr, data_test$TARGET_BAD_FLAG)
plr3 = performance(plr2, "tpr" , "fpr")
```

```r
plot(plr3,col="gold")
abline(0,1,lty=2)
legend("bottomright", c("LOGISTIC REGRESSION FWD"), col=c("gold"), bty="y", lty=1)
```
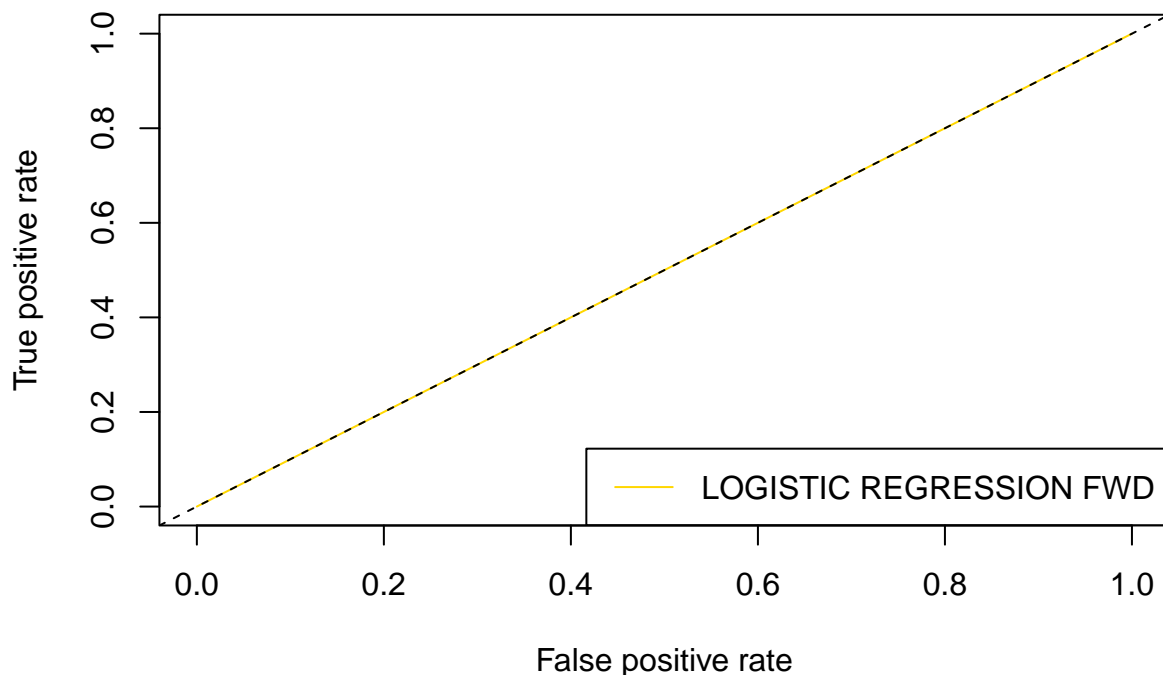


```r
treeVars = t1E$variable.importance
treeVars = names(treeVars)
treeVarsPlus = paste(treeVars, collapse ="+")
F = as.formula(paste("TARGET_BAD_FLAG ~", treeVarsPlus))
```

```r
tree_LR = glm(F, family = "binomial", data=data_train)
theLower_LR = lm(TARGET_BAD_FLAG ~ 1, data=data_train)
```

```r
summary(tree_LR)
```

```
##
## Call:
## glm(formula = F, family = "binomial", data = data_train)
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.697e+00  3.910e-01 -12.014  < 2e-16 ***
## M_DEBTINC    2.782e+00  1.066e-01  26.103  < 2e-16 ***
## IMP_DEBTINC  8.956e-02  9.640e-03   9.290  < 2e-16 ***
## IMP_DELINQ   6.802e-01  5.169e-02  13.159  < 2e-16 ***
## IMP_CLAGE   -6.253e-03  7.569e-04  -8.261  < 2e-16 ***
## LOAN        -7.340e-06  5.046e-06  -1.455  0.14577
## M_VALUE      3.887e+00  4.956e-01   7.842 4.43e-15 ***
## IMP_VALUE    4.458e-06  1.378e-06   3.236  0.00121 **
## IMP_MORTDUE -3.540e-06  1.932e-06  -1.832  0.06692 .
## IMP_CLNO    -7.701e-03  5.556e-03  -1.386  0.16572
## IMP_YOJ     -2.077e-02  7.871e-03  -2.639  0.00830 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 2533.8  on 4131  degrees of freedom
## AIC: 2555.8
##
## Number of Fisher Scoring iterations: 6
```

```r
summary(theLower_LR)
```

```
##
## Call:
## lm(formula = TARGET_BAD_FLAG ~ 1, data = data_train)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.2009 -0.2009 -0.2009 -0.2009  0.7991
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.200869   0.006226   32.26   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4007 on 4141 degrees of freedom
```

```r
lrt_model = stepAIC(theLower_LR, direction = "both", scope = list(lower=theLower_LR, upper=tree_LR))
```

```
## Start:  AIC=-7575.09
## TARGET_BAD_FLAG ~ 1
##
##                Df Sum of Sq    RSS      AIC
## + M_DEBTINC     1   199.727 465.15 -9052.8
## + IMP_DELINQ    1    71.248 593.63 -8042.6
## + M_VALUE       1    44.745 620.13 -7861.7
## + IMP_CLAGE     1    18.820 646.06 -7692.0
## + IMP_DEBTINC   1    16.351 648.53 -7676.2
## + LOAN          1     3.253 661.62 -7593.4
## + IMP_YOJ       1     1.762 663.11 -7584.1
## + IMP_MORTDUE   1     0.766 664.11 -7577.9
## + IMP_VALUE     1     0.336 664.54 -7575.2
## <none>                     664.88 -7575.1
## + IMP_CLNO      1     0.006 664.87 -7573.1
##
## Step:  AIC=-9052.79
## TARGET_BAD_FLAG ~ M_DEBTINC
##
##                Df Sum of Sq    RSS      AIC
## + IMP_DELINQ    1    31.593 433.56 -9342.1
## + M_VALUE       1    18.102 447.05 -9215.2
## + IMP_DEBTINC   1    10.401 454.75 -9144.5
## + IMP_CLAGE     1     8.425 456.73 -9126.5
## + IMP_YOJ       1     1.463 463.69 -9063.8
## <none>                     465.15 -9052.8
## + LOAN          1     0.198 464.95 -9052.6
## + IMP_CLNO      1     0.031 465.12 -9051.1
## + IMP_VALUE     1     0.021 465.13 -9051.0
## + IMP_MORTDUE   1     0.002 465.15 -9050.8
## - M_DEBTINC     1   199.727 664.88 -7575.1
##
## Step:  AIC=-9342.12
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ
##
##                Df Sum of Sq    RSS      AIC
## + M_VALUE       1    12.520 421.04 -9461.5
## + IMP_CLAGE     1    10.013 423.54 -9436.9
## + IMP_DEBTINC   1     9.554 424.00 -9432.4
## + IMP_YOJ       1     2.293 431.26 -9362.1
## + IMP_CLNO      1     1.088 432.47 -9350.5
## <none>                     433.56 -9342.1
## + LOAN          1     0.160 433.40 -9341.7
## + IMP_VALUE     1     0.062 433.50 -9340.7
## + IMP_MORTDUE   1     0.008 433.55 -9340.2
## - IMP_DELINQ    1    31.593 465.15 -9052.8
## - M_DEBTINC     1   160.072 593.63 -8042.6
##
## Step:  AIC=-9461.49
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE
##
```

```
##                Df Sum of Sq    RSS     AIC
## + IMP_DEBTINC  1     10.311 410.73 -9562.2
## + IMP_CLAGE    1      9.622 411.42 -9555.2
## + IMP_YOJ      1      2.309 418.73 -9482.3
## + IMP_CLNO     1      0.853 420.18 -9467.9
## + LOAN         1      0.206 420.83 -9461.5
## <none>                      421.04 -9461.5
## + IMP_VALUE    1      0.105 420.93 -9460.5
## + IMP_MORTDUE  1      0.021 421.02 -9459.7
## - M_VALUE      1     12.520 433.56 -9342.1
## - IMP_DELINQ   1     26.011 447.05 -9215.2
## - M_DEBTINC    1    143.748 564.79 -8246.9
##
## Step:  AIC=-9562.19
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC
##
##                Df Sum of Sq    RSS     AIC
## + IMP_CLAGE    1      8.884 401.84 -9650.8
## + IMP_CLNO     1      1.981 408.75 -9580.2
## + IMP_YOJ      1      1.850 408.88 -9578.9
## + LOAN         1      0.447 410.28 -9564.7
## + IMP_MORTDUE  1      0.310 410.42 -9563.3
## <none>                      410.73 -9562.2
## + IMP_VALUE    1      0.000 410.73 -9560.2
## - IMP_DEBTINC  1     10.311 421.04 -9461.5
## - M_VALUE      1     13.277 424.00 -9432.4
## - IMP_DELINQ   1     25.074 435.80 -9318.8
## - M_DEBTINC    1    138.981 549.71 -8357.0
##
## Step:  AIC=-9650.76
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##     IMP_CLAGE
##
##                Df Sum of Sq    RSS     AIC
## + IMP_YOJ      1      0.699 401.14 -9656.0
## + IMP_CLNO     1      0.489 401.35 -9653.8
## + IMP_VALUE    1      0.247 401.60 -9651.3
## <none>                      401.84 -9650.8
## + LOAN         1      0.172 401.67 -9650.5
## + IMP_MORTDUE  1      0.034 401.81 -9649.1
## - IMP_CLAGE    1      8.884 410.73 -9562.2
## - IMP_DEBTINC  1      9.573 411.42 -9555.2
## - M_VALUE      1     12.861 414.70 -9522.3
## - IMP_DELINQ   1     26.496 428.34 -9388.3
## - M_DEBTINC    1    130.306 532.15 -8489.4
##
## Step:  AIC=-9655.98
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##     IMP_CLAGE + IMP_YOJ
##
##                Df Sum of Sq    RSS     AIC
## + IMP_CLNO     1      0.489 400.65 -9659.0
## + IMP_VALUE    1      0.234 400.91 -9656.4
## <none>                      401.14 -9656.0
```

```
## + LOAN          1      0.118 401.02 -9655.2
## + IMP_MORTDUE  1      0.074 401.07 -9654.7
## - IMP_YOJ       1      0.699 401.84 -9650.8
## - IMP_CLAGE     1      7.733 408.88 -9578.9
## - IMP_DEBTINC   1      9.328 410.47 -9562.8
## - M_VALUE       1     12.881 414.02 -9527.1
## - IMP_DELINQ    1     26.841 427.98 -9389.7
## - M_DEBTINC     1    130.349 531.49 -8492.5
##
## Step:  AIC=-9659.03
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##      IMP_CLAGE + IMP_YOJ + IMP_CLNO
##
##                Df Sum of Sq    RSS      AIC
## + IMP_VALUE    1      0.445 400.21 -9661.6
## <none>                      400.65 -9659.0
## + LOAN          1      0.096 400.56 -9658.0
## + IMP_MORTDUE  1      0.004 400.65 -9657.1
## - IMP_CLNO     1      0.489 401.14 -9656.0
## - IMP_YOJ       1      0.699 401.35 -9653.8
## - IMP_CLAGE     1      6.404 407.06 -9595.4
## - IMP_DEBTINC   1      9.776 410.43 -9561.2
## - M_VALUE       1     12.745 413.40 -9531.3
## - IMP_DELINQ    1     27.326 427.98 -9387.7
## - M_DEBTINC     1    130.302 530.96 -8494.7
##
## Step:  AIC=-9661.63
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##      IMP_CLAGE + IMP_YOJ + IMP_CLNO + IMP_VALUE
##
##                Df Sum of Sq    RSS      AIC
## + IMP_MORTDUE  1      0.734 399.48 -9667.2
## + LOAN          1      0.299 399.91 -9662.7
## <none>                      400.21 -9661.6
## - IMP_VALUE    1      0.445 400.65 -9659.0
## - IMP_YOJ       1      0.681 400.89 -9656.6
## - IMP_CLNO     1      0.700 400.91 -9656.4
## - IMP_CLAGE     1      6.702 406.91 -9594.8
## - IMP_DEBTINC   1      9.415 409.62 -9567.3
## - M_VALUE       1     12.789 413.00 -9533.3
## - IMP_DELINQ    1     27.653 427.86 -9386.9
## - M_DEBTINC     1    130.655 530.86 -8493.4
##
## Step:  AIC=-9667.23
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##      IMP_CLAGE + IMP_YOJ + IMP_CLNO + IMP_VALUE + IMP_MORTDUE
##
##                Df Sum of Sq    RSS      AIC
## + LOAN          1      0.353 399.12 -9668.9
## <none>                      399.48 -9667.2
## - IMP_CLNO     1      0.429 399.90 -9664.8
## - IMP_MORTDUE  1      0.734 400.21 -9661.6
## - IMP_YOJ       1      0.885 400.36 -9660.1
## - IMP_VALUE    1      1.174 400.65 -9657.1
```

```
## - IMP_CLAGE     1      6.788 406.26 -9599.4
## - IMP_DEBTINC   1      9.619 409.09 -9570.7
## - M_VALUE       1     13.112 412.59 -9535.5
## - IMP_DELINQ    1     27.680 427.16 -9391.7
## - M_DEBTINC     1    129.307 528.78 -8507.7
##
## Step:  AIC=-9668.89
## TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE + IMP_DEBTINC +
##     IMP_CLAGE + IMP_YOJ + IMP_CLNO + IMP_VALUE + IMP_MORTDUE +
##     LOAN
##
##              Df Sum of Sq    RSS     AIC
## <none>                    399.12 -9668.9
## - LOAN        1      0.353 399.48 -9667.2
## - IMP_CLNO    1      0.441 399.56 -9666.3
## - IMP_YOJ     1      0.784 399.91 -9662.8
## - IMP_MORTDUE 1      0.787 399.91 -9662.7
## - IMP_VALUE   1      1.435 400.56 -9656.0
## - IMP_CLAGE   1      6.721 405.84 -9601.7
## - IMP_DEBTINC 1      9.769 408.89 -9570.7
## - M_VALUE     1     13.221 412.34 -9535.9
## - IMP_DELINQ  1     27.628 426.75 -9393.7
## - M_DEBTINC   1    127.194 526.32 -8525.1
```

```
summary(lrt_model)
```

```
##
## Call:
## lm(formula = TARGET_BAD_FLAG ~ M_DEBTINC + IMP_DELINQ + M_VALUE +
##     IMP_DEBTINC + IMP_CLAGE + IMP_YOJ + IMP_CLNO + IMP_VALUE +
##     IMP_MORTDUE + LOAN, data = data_train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.86882 -0.12613 -0.05940  0.02856  1.34793
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.340e-02  2.573e-02  -0.910 0.362993
## M_DEBTINC    4.468e-01  1.232e-02  36.283  < 2e-16 ***
## IMP_DELINQ   7.667e-02  4.534e-03  16.910  < 2e-16 ***
## M_VALUE      4.147e-01  3.545e-02  11.698  < 2e-16 ***
## IMP_DEBTINC  6.227e-03  6.192e-04  10.055  < 2e-16 ***
## IMP_CLAGE   -5.024e-04  6.023e-05  -8.341  < 2e-16 ***
## IMP_YOJ     -1.964e-03  6.896e-04  -2.848 0.004417 **
## IMP_CLNO    -1.134e-03  5.305e-04  -2.137 0.032648 *
## IMP_VALUE    5.467e-07  1.418e-07   3.854 0.000118 ***
## IMP_MORTDUE -5.345e-07  1.872e-07  -2.855 0.004326 **
## LOAN        -8.709e-07  4.558e-07  -1.911 0.056121 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3108 on 4131 degrees of freedom
## Multiple R-squared:  0.3997, Adjusted R-squared:  0.3983
```

```
## F-statistic: 275.1 on 10 and 4131 DF,  p-value: < 2.2e-16
```

```r
plrt = predict(lrt_model, data_test, type = "response")
plrt2 = prediction(plrt, data_test$TARGET_BAD_FLAG)
plrt3= performance(plrt2, "tpr", "fpr")
```

```r
plot(pt3, col = "green")
plot(pr3, col = "red", add=TRUE)
plot(pg3, col = "blue", add=TRUE)
plot(plr3, col = "gold", add=TRUE)
plot(plrt3, col = "gray", add=TRUE)
abline(0,1,lty=2)
legend("bottomright", c("TREE","RANDOM FOREST","GRADIENT BOOSTING","LOGIT REG BACK","LOGIT REG TREE"),
```
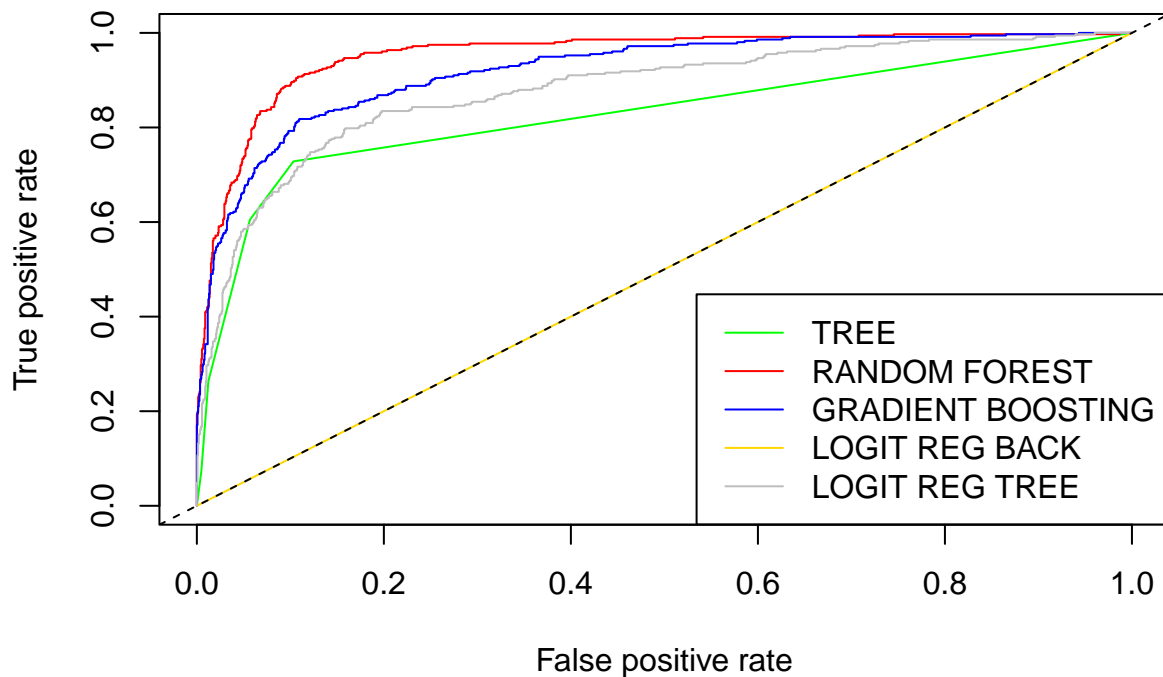


```r
aucT = performance(pt2, "auc")@y.values
aucR = performance(pr2, "auc")@y.values
aucG = performance(pg2, "auc")@y.values
aucLR = performance(plr2, "auc")@y.values
aucLRT = performance(plrt2, "auc")@y.values
```

```r
print(paste("TREE AUC=", aucT ))
```

```
## [1] "TREE AUC= 0.826618121581281"
```

```r
print(paste("RF AUC=", aucR ))
```

```
## [1] "RF AUC= 0.953436405362943"
```

```r
print(paste("GB AUC=", aucG ))
```

```
## [1] "GB AUC= 0.920521802150007"
```

```r
print(paste("LR AUC=", aucLR ))
```

```
## [1] "LR AUC= 0.5"
```

```r
print(paste("LRT AUC=", aucLRT ))
```

```
## [1] "LRT AUC= 0.878547175201358"
```

The ROC curves for all trees are optimal According to the results of my code Random Forest is slightly better than remaining models and I recommend random forest.

```r
SEED=1
set.seed(SEED)
```

```r
data_flag1= data
data_flag1$TARGET_BAD_FLAG= NULL
head(data_flag1)
```

LINEAR REGRESSION

```
##    TARGET_LOSS_AMT LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE IMP_YOJ M_YOJ
## 1              641 1100       25860         0     39025       0    10.5     0
## 2             1109 1300       70053         0     68400       0     7.0     0
## 3              767 1500       13500         0     16700       0     4.0     0
## 4             1425 1500       65000         1     89000       1     7.0     1
## 5                0 1700       97800         0    112000       0     3.0     0
## 6              335 1700       30548         0     40320       0     9.0     0
##    IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE IMP_NINQ M_NINQ
## 1          0       0          0        0  94.36667       0        1      0
## 2          0       0          2        0 121.83333       0        0      0
## 3          0       0          0        0 149.46667       0        1      0
## 4          1       1          1        1 174.00000       1        1      1
## 5          0       0          0        0  93.33333       0        0      0
## 6          0       0          0        0 101.46600       0        1      0
##    IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr FLAG.Job.Office
## 1         9      0    35.00000         1            0               0
## 2        14      0    35.00000         1            0               0
```

```
## 3       10    0   35.00000            1             0             0
## 4       20    1   35.00000            1             0             0
## 5       14    0   35.00000            1             0             1
## 6        8    0   37.11361            0             0             0
##   FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1              1                0              0             0
## 2              1                0              0             0
## 3              1                0              0             0
## 4              0                0              0             0
## 5              0                0              0             0
## 6              1                0              0             0
##   FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
## 2                   0                   1
## 3                   0                   1
## 4                   0                   0
## 5                   0                   1
## 6                   0                   1
```

```
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.7,0.3))
data_train1= data_flag1[FLAG, ]
data_test1= data_flag1[! FLAG, ]
```

```
dim(data_flag1)
```

```
## [1] 5960    28
```

```
dim(data_train1)
```

```
## [1] 4142    28
```

```
dim(data_test1)
```

```
## [1] 1818    28
```

```
theUpper_LR1 = lm(TARGET_LOSS_AMT ~ ., data=data_train1)
theLower_LR1 = lm(TARGET_LOSS_AMT ~ 1, data=data_train1)
summary(theUpper_LR1)
```

```
##
## Call:
## lm(formula = TARGET_LOSS_AMT ~ ., data = data_train1)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -32389  -2537   -335   1536  58383
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -6.167e+03  7.462e+02  -8.264  < 2e-16 ***
## LOAN             1.407e-01  8.541e-03  16.476  < 2e-16 ***
```

```
## IMP_MORTDUE        -7.051e-03  3.449e-03  -2.044 0.040992 *
## M_MORTDUE           9.756e+02  3.588e+02   2.719 0.006582 **
## IMP_VALUE           1.189e-02  2.632e-03   4.516 6.49e-06 ***
## M_VALUE             5.695e+03  6.379e+02   8.927  < 2e-16 ***
## IMP_YOJ            -4.460e+01  1.252e+01  -3.563 0.000371 ***
## M_YOJ              -9.450e+02  3.466e+02  -2.727 0.006423 **
## IMP_DEROG           9.082e+02  1.145e+02   7.929 2.82e-15 ***
## M_DEROG            -2.791e+03  4.350e+02  -6.416 1.56e-10 ***
## IMP_DELINQ          1.794e+03  8.430e+01  21.276  < 2e-16 ***
## M_DELINQ           -1.426e+03  5.550e+02  -2.570 0.010214 *
## IMP_CLAGE          -8.837e+00  1.102e+00  -8.018 1.39e-15 ***
## M_CLAGE             5.643e+02  8.113e+02   0.696 0.486760
## IMP_NINQ            2.198e+02  5.574e+01   3.944 8.15e-05 ***
## M_NINQ             -5.651e+01  5.264e+02  -0.107 0.914523
## IMP_CLNO            4.846e+01  1.005e+01   4.820 1.49e-06 ***
## M_CLNO              2.246e+03  1.041e+03   2.157 0.031026 *
## IMP_DEBTINC         1.104e+02  1.144e+01   9.649  < 2e-16 ***
## M_DEBTINC           6.305e+03  2.246e+02  28.069  < 2e-16 ***
## FLAG.Job.Mgr        6.379e+02  5.473e+02   1.166 0.243855
## FLAG.Job.Office     3.706e+02  5.403e+02   0.686 0.492845
## FLAG.Job.Other      9.849e+02  5.089e+02   1.935 0.053027 .
## FLAG.Job.ProfExe    6.239e+02  5.342e+02   1.168 0.242856
## FLAG.Job.Sales      3.390e+03  8.134e+02   4.168 3.14e-05 ***
## FLAG.Job.Self       2.594e+03  6.998e+02   3.707 0.000212 ***
## FLAG.Reason.DebtCon -5.226e+02  4.837e+02  -1.080 0.279986
## FLAG.Reason.HomeImp -1.028e+03  4.914e+02  -2.093 0.036435 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5531 on 4114 degrees of freedom
## Multiple R-squared:  0.4354, Adjusted R-squared:  0.4317
## F-statistic: 117.5 on 27 and 4114 DF,  p-value: < 2.2e-16
```

```r
summary(theLower_LR1)
```

```
##
## Call:
## lm(formula = TARGET_LOSS_AMT ~ 1, data = data_train1)
##
## Residuals:
##    Min    1Q Median    3Q    Max
##  -2726  -2726  -2726  -2726  76261
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)     2726        114   23.92   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7337 on 4141 degrees of freedom
```

```r
lr_model1 = stepAIC(theUpper_LR1, direction = "backward", scope = list(lower=theLower_LR1, upper = theUp
```

```
## Start:  AIC=71420.12
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + M_CLAGE + IMP_NINQ + M_NINQ + IMP_CLNO +
##     M_CLNO + IMP_DEBTINC + M_DEBTINC + FLAG.Job.Mgr + FLAG.Job.Office +
##     FLAG.Job.Other + FLAG.Job.ProfExe + FLAG.Job.Sales + FLAG.Job.Self +
##     FLAG.Reason.DebtCon + FLAG.Reason.HomeImp
##
##                         Df  Sum of Sq         RSS    AIC
## - M_NINQ                 1  3.5246e+05  1.2585e+11  71418
## - FLAG.Job.Office        1  1.4389e+07  1.2586e+11  71419
## - M_CLAGE                1  1.4798e+07  1.2586e+11  71419
## - FLAG.Reason.DebtCon    1  3.5712e+07  1.2588e+11  71419
## - FLAG.Job.Mgr           1  4.1558e+07  1.2589e+11  71419
## - FLAG.Job.ProfExe       1  4.1734e+07  1.2589e+11  71419
## <none>                                  1.2585e+11  71420
## - FLAG.Job.Other         1  1.1457e+08  1.2596e+11  71422
## - IMP_MORTDUE            1  1.2783e+08  1.2597e+11  71422
## - FLAG.Reason.HomeImp    1  1.3397e+08  1.2598e+11  71423
## - M_CLNO                 1  1.4239e+08  1.2599e+11  71423
## - M_DELINQ               1  2.0199e+08  1.2605e+11  71425
## - M_MORTDUE              1  2.2609e+08  1.2607e+11  71426
## - M_YOJ                  1  2.2744e+08  1.2607e+11  71426
## - IMP_YOJ                1  3.8825e+08  1.2623e+11  71431
## - FLAG.Job.Self          1  4.2044e+08  1.2627e+11  71432
## - IMP_NINQ               1  4.7583e+08  1.2632e+11  71434
## - FLAG.Job.Sales         1  5.3135e+08  1.2638e+11  71436
## - IMP_VALUE              1  6.2376e+08  1.2647e+11  71439
## - IMP_CLNO               1  7.1072e+08  1.2656e+11  71441
## - M_DEROG                1  1.2591e+09  1.2710e+11  71459
## - IMP_DEROG              1  1.9232e+09  1.2777e+11  71481
## - IMP_CLAGE              1  1.9665e+09  1.2781e+11  71482
## - M_VALUE                1  2.4375e+09  1.2828e+11  71498
## - IMP_DEBTINC            1  2.8480e+09  1.2869e+11  71511
## - LOAN                   1  8.3042e+09  1.3415e+11  71683
## - IMP_DELINQ             1  1.3847e+10  1.3969e+11  71850
## - M_DEBTINC              1  2.4101e+10  1.4995e+11  72144
##
## Step:  AIC=71418.13
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + M_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO +
##     IMP_DEBTINC + M_DEBTINC + FLAG.Job.Mgr + FLAG.Job.Office +
##     FLAG.Job.Other + FLAG.Job.ProfExe + FLAG.Job.Sales + FLAG.Job.Self +
##     FLAG.Reason.DebtCon + FLAG.Reason.HomeImp
##
##                         Df  Sum of Sq         RSS    AIC
## - FLAG.Job.Office        1  1.4504e+07  1.2586e+11  71417
## - M_CLAGE                1  1.4938e+07  1.2586e+11  71417
## - FLAG.Reason.DebtCon    1  3.5706e+07  1.2588e+11  71417
## - FLAG.Job.Mgr           1  4.1764e+07  1.2589e+11  71418
## - FLAG.Job.ProfExe       1  4.1931e+07  1.2589e+11  71418
## <none>                                  1.2585e+11  71418
## - FLAG.Job.Other         1  1.1491e+08  1.2596e+11  71420
```

```
## - IMP_MORTDUE          1 1.2780e+08 1.2597e+11 71420
## - FLAG.Reason.HomeImp   1 1.3398e+08 1.2598e+11 71421
## - M_CLNO                1 1.4626e+08 1.2599e+11 71421
## - M_MORTDUE             1 2.2584e+08 1.2607e+11 71424
## - M_YOJ                 1 2.3039e+08 1.2608e+11 71424
## - M_DELINQ              1 2.6415e+08 1.2611e+11 71425
## - IMP_YOJ               1 3.8824e+08 1.2623e+11 71429
## - FLAG.Job.Self         1 4.2047e+08 1.2627e+11 71430
## - IMP_NINQ              1 4.7986e+08 1.2633e+11 71432
## - FLAG.Job.Sales        1 5.3338e+08 1.2638e+11 71434
## - IMP_VALUE             1 6.2345e+08 1.2647e+11 71437
## - IMP_CLNO              1 7.1050e+08 1.2656e+11 71439
## - M_DEROG               1 1.2679e+09 1.2711e+11 71458
## - IMP_DEROG             1 1.9257e+09 1.2777e+11 71479
## - IMP_CLAGE             1 1.9665e+09 1.2781e+11 71480
## - M_VALUE               1 2.4434e+09 1.2829e+11 71496
## - IMP_DEBTINC           1 2.8779e+09 1.2872e+11 71510
## - LOAN                  1 8.3252e+09 1.3417e+11 71681
## - IMP_DELINQ            1 1.3858e+10 1.3970e+11 71849
## - M_DEBTINC             1 2.4108e+10 1.4995e+11 72142
##
## Step:  AIC=71416.61
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + M_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO +
##     IMP_DEBTINC + M_DEBTINC + FLAG.Job.Mgr + FLAG.Job.Other +
##     FLAG.Job.ProfExe + FLAG.Job.Sales + FLAG.Job.Self + FLAG.Reason.DebtCon +
##     FLAG.Reason.HomeImp
##
##                         Df  Sum of Sq        RSS    AIC
## - M_CLAGE               1 1.1611e+07 1.2587e+11 71415
## - FLAG.Reason.DebtCon   1 2.8931e+07 1.2589e+11 71416
## - FLAG.Job.Mgr          1 3.3928e+07 1.2589e+11 71416
## - FLAG.Job.ProfExe      1 3.7375e+07 1.2590e+11 71416
## <none>                             1.2586e+11 71417
## - FLAG.Reason.HomeImp   1 1.2210e+08 1.2598e+11 71419
## - IMP_MORTDUE           1 1.3002e+08 1.2599e+11 71419
## - M_CLNO                1 1.3662e+08 1.2600e+11 71419
## - M_MORTDUE             1 2.1870e+08 1.2608e+11 71422
## - M_YOJ                 1 2.3425e+08 1.2609e+11 71422
## - FLAG.Job.Other        1 2.3818e+08 1.2610e+11 71422
## - M_DELINQ              1 2.5831e+08 1.2612e+11 71423
## - IMP_YOJ               1 3.9080e+08 1.2625e+11 71427
## - IMP_NINQ              1 4.7697e+08 1.2634e+11 71430
## - FLAG.Job.Self         1 5.6184e+08 1.2642e+11 71433
## - IMP_VALUE             1 6.2667e+08 1.2649e+11 71435
## - FLAG.Job.Sales        1 6.4442e+08 1.2650e+11 71436
## - IMP_CLNO              1 7.1373e+08 1.2657e+11 71438
## - M_DEROG               1 1.2731e+09 1.2713e+11 71456
## - IMP_DEROG             1 1.9173e+09 1.2778e+11 71477
## - IMP_CLAGE             1 1.9533e+09 1.2781e+11 71478
## - M_VALUE               1 2.4410e+09 1.2830e+11 71494
## - IMP_DEBTINC           1 2.9273e+09 1.2879e+11 71510
## - LOAN                  1 8.3163e+09 1.3418e+11 71680
```

```
## - IMP_DELINQ                1 1.3900e+10 1.3976e+11 71849
## - M_DEBTINC                 1 2.4143e+10 1.5000e+11 72141
##
## Step:  AIC=71414.99
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO + IMP_DEBTINC +
##     M_DEBTINC + FLAG.Job.Mgr + FLAG.Job.Other + FLAG.Job.ProfExe +
##     FLAG.Job.Sales + FLAG.Job.Self + FLAG.Reason.DebtCon + FLAG.Reason.HomeImp
##
##                            Df  Sum of Sq        RSS    AIC
## - FLAG.Reason.DebtCon       1 3.2415e+07 1.2590e+11 71414
## - FLAG.Job.Mgr              1 3.3084e+07 1.2591e+11 71414
## - FLAG.Job.ProfExe          1 3.6162e+07 1.2591e+11 71414
## <none>                                   1.2587e+11 71415
## - IMP_MORTDUE               1 1.2503e+08 1.2600e+11 71417
## - FLAG.Reason.HomeImp       1 1.3075e+08 1.2600e+11 71417
## - M_MORTDUE                 1 2.2243e+08 1.2609e+11 71420
## - M_YOJ                     1 2.3442e+08 1.2611e+11 71421
## - FLAG.Job.Other            1 2.3678e+08 1.2611e+11 71421
## - M_DELINQ                  1 2.6349e+08 1.2614e+11 71422
## - IMP_YOJ                   1 3.9885e+08 1.2627e+11 71426
## - IMP_NINQ                  1 4.8244e+08 1.2635e+11 71429
## - M_CLNO                    1 5.2769e+08 1.2640e+11 71430
## - FLAG.Job.Self             1 5.5803e+08 1.2643e+11 71431
## - IMP_VALUE                 1 6.2261e+08 1.2649e+11 71433
## - FLAG.Job.Sales            1 6.4188e+08 1.2651e+11 71434
## - IMP_CLNO                  1 7.0567e+08 1.2658e+11 71436
## - M_DEROG                   1 1.2720e+09 1.2714e+11 71455
## - IMP_DEROG                 1 1.9307e+09 1.2780e+11 71476
## - IMP_CLAGE                 1 1.9435e+09 1.2782e+11 71476
## - M_VALUE                   1 2.4363e+09 1.2831e+11 71492
## - IMP_DEBTINC               1 2.9166e+09 1.2879e+11 71508
## - LOAN                      1 8.3244e+09 1.3420e+11 71678
## - IMP_DELINQ                1 1.3889e+10 1.3976e+11 71847
## - M_DEBTINC                 1 2.4178e+10 1.5005e+11 72141
##
## Step:  AIC=71414.06
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO + IMP_DEBTINC +
##     M_DEBTINC + FLAG.Job.Mgr + FLAG.Job.Other + FLAG.Job.ProfExe +
##     FLAG.Job.Sales + FLAG.Job.Self + FLAG.Reason.HomeImp
##
##                            Df  Sum of Sq        RSS    AIC
## - FLAG.Job.Mgr              1 2.8951e+07 1.2593e+11 71413
## - FLAG.Job.ProfExe          1 3.0177e+07 1.2593e+11 71413
## <none>                                   1.2590e+11 71414
## - IMP_MORTDUE               1 1.2798e+08 1.2603e+11 71416
## - M_YOJ                     1 2.1556e+08 1.2612e+11 71419
## - FLAG.Job.Other            1 2.2152e+08 1.2613e+11 71419
## - FLAG.Reason.HomeImp       1 2.2951e+08 1.2613e+11 71420
## - M_MORTDUE                 1 2.4234e+08 1.2615e+11 71420
## - M_DELINQ                  1 2.6331e+08 1.2617e+11 71421
```

```
## - IMP_YOJ               1 3.9098e+08 1.2630e+11 71425
## - IMP_NINQ              1 4.8232e+08 1.2639e+11 71428
## - FLAG.Job.Self         1 5.5359e+08 1.2646e+11 71430
## - M_CLNO                1 6.1654e+08 1.2652e+11 71432
## - FLAG.Job.Sales        1 6.2636e+08 1.2653e+11 71433
## - IMP_VALUE             1 6.4069e+08 1.2655e+11 71433
## - IMP_CLNO              1 7.0088e+08 1.2661e+11 71435
## - M_DEROG               1 1.2917e+09 1.2720e+11 71454
## - IMP_CLAGE             1 1.9245e+09 1.2783e+11 71475
## - IMP_DEROG             1 1.9314e+09 1.2784e+11 71475
## - M_VALUE               1 2.4817e+09 1.2839e+11 71493
## - IMP_DEBTINC           1 2.8949e+09 1.2880e+11 71506
## - LOAN                  1 8.2938e+09 1.3420e+11 71676
## - IMP_DELINQ            1 1.4036e+10 1.3994e+11 71850
## - M_DEBTINC             1 2.4162e+10 1.5007e+11 72139
##
## Step:  AIC=71413.01
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO + IMP_DEBTINC +
##     M_DEBTINC + FLAG.Job.Other + FLAG.Job.ProfExe + FLAG.Job.Sales +
##     FLAG.Job.Self + FLAG.Reason.HomeImp
##
##                         Df  Sum of Sq         RSS    AIC
## - FLAG.Job.ProfExe       1 1.1519e+07 1.2594e+11 71411
## <none>                               1.2593e+11 71413
## - IMP_MORTDUE            1 1.1924e+08 1.2605e+11 71415
## - FLAG.Job.Other         1 1.9904e+08 1.2613e+11 71418
## - M_YOJ                  1 2.1459e+08 1.2615e+11 71418
## - M_MORTDUE              1 2.3395e+08 1.2617e+11 71419
## - FLAG.Reason.HomeImp    1 2.3452e+08 1.2617e+11 71419
## - M_DELINQ               1 2.6039e+08 1.2619e+11 71420
## - IMP_YOJ                1 3.7964e+08 1.2631e+11 71423
## - IMP_NINQ               1 4.9548e+08 1.2643e+11 71427
## - FLAG.Job.Self          1 5.2479e+08 1.2646e+11 71428
## - M_CLNO                 1 5.9562e+08 1.2653e+11 71431
## - FLAG.Job.Sales         1 5.9773e+08 1.2653e+11 71431
## - IMP_VALUE              1 6.3879e+08 1.2657e+11 71432
## - IMP_CLNO               1 7.0308e+08 1.2664e+11 71434
## - M_DEROG                1 1.2953e+09 1.2723e+11 71453
## - IMP_CLAGE              1 1.9280e+09 1.2786e+11 71474
## - IMP_DEROG              1 1.9464e+09 1.2788e+11 71475
## - M_VALUE                1 2.4793e+09 1.2841e+11 71492
## - IMP_DEBTINC            1 2.9129e+09 1.2885e+11 71506
## - LOAN                   1 8.2784e+09 1.3421e+11 71675
## - IMP_DELINQ             1 1.4095e+10 1.4003e+11 71850
## - M_DEBTINC              1 2.4218e+10 1.5015e+11 72140
##
## Step:  AIC=71411.39
## TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE + IMP_VALUE +
##     M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG + IMP_DELINQ +
##     M_DELINQ + IMP_CLAGE + IMP_NINQ + IMP_CLNO + M_CLNO + IMP_DEBTINC +
##     M_DEBTINC + FLAG.Job.Other + FLAG.Job.Sales + FLAG.Job.Self +
##     FLAG.Reason.HomeImp
```

```
##
##                      Df  Sum of Sq         RSS    AIC
## <none>                              1.2594e+11 71411
## - IMP_MORTDUE        1 1.1543e+08 1.2606e+11 71413
## - FLAG.Job.Other     1 1.9410e+08 1.2614e+11 71416
## - M_YOJ              1 2.1752e+08 1.2616e+11 71417
## - M_MORTDUE          1 2.2920e+08 1.2617e+11 71417
## - FLAG.Reason.HomeImp 1 2.3046e+08 1.2618e+11 71417
## - M_DELINQ           1 2.5770e+08 1.2620e+11 71418
## - IMP_YOJ            1 3.8259e+08 1.2633e+11 71422
## - IMP_NINQ           1 4.9230e+08 1.2644e+11 71426
## - FLAG.Job.Self      1 5.1615e+08 1.2646e+11 71426
## - FLAG.Job.Sales     1 5.8630e+08 1.2653e+11 71429
## - M_CLNO             1 5.9038e+08 1.2654e+11 71429
## - IMP_VALUE          1 6.5743e+08 1.2660e+11 71431
## - IMP_CLNO           1 7.2048e+08 1.2667e+11 71433
## - M_DEROG            1 1.3193e+09 1.2726e+11 71453
## - IMP_CLAGE          1 1.9181e+09 1.2786e+11 71472
## - IMP_DEROG          1 1.9389e+09 1.2788e+11 71473
## - M_VALUE            1 2.4799e+09 1.2842e+11 71490
## - IMP_DEBTINC        1 2.9025e+09 1.2885e+11 71504
## - LOAN               1 8.2679e+09 1.3421e+11 71673
## - IMP_DELINQ         1 1.4083e+10 1.4003e+11 71848
## - M_DEBTINC          1 2.4293e+10 1.5024e+11 72140
```

`summary`(lr_model1)

```
##
## Call:
## lm(formula = TARGET_LOSS_AMT ~ LOAN + IMP_MORTDUE + M_MORTDUE +
##      IMP_VALUE + M_VALUE + IMP_YOJ + M_YOJ + IMP_DEROG + M_DEROG +
##      IMP_DELINQ + M_DELINQ + IMP_CLAGE + IMP_NINQ + IMP_CLNO +
##      M_CLNO + IMP_DEBTINC + M_DEBTINC + FLAG.Job.Other + FLAG.Job.Sales +
##      FLAG.Job.Self + FLAG.Reason.HomeImp, data = data_train1)
##
## Residuals:
##    Min    1Q Median    3Q    Max
## -32477  -2520   -340   1525  58418
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       -6.183e+03  4.874e+02 -12.686  < 2e-16 ***
## LOAN               1.398e-01  8.498e-03  16.446  < 2e-16 ***
## IMP_MORTDUE       -6.647e-03  3.420e-03  -1.943 0.052055 .
## M_MORTDUE          9.695e+02  3.541e+02   2.738 0.006204 **
## IMP_VALUE          1.214e-02  2.617e-03   4.637 3.64e-06 ***
## M_VALUE            5.727e+03  6.359e+02   9.007  < 2e-16 ***
## IMP_YOJ           -4.409e+01  1.246e+01  -3.538 0.000408 ***
## M_YOJ             -9.121e+02  3.419e+02  -2.668 0.007671 **
## IMP_DEROG          9.088e+02  1.141e+02   7.964 2.14e-15 ***
## M_DEROG           -2.840e+03  4.323e+02  -6.570 5.67e-11 ***
## IMP_DELINQ         1.801e+03  8.391e+01  21.464  < 2e-16 ***
## M_DELINQ          -1.431e+03  4.929e+02  -2.903 0.003710 **
## IMP_CLAGE         -8.680e+00  1.096e+00  -7.921 3.00e-15 ***
```

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```
## IMP_NINQ               2.226e+02  5.546e+01   4.013 6.10e-05 ***
## IMP_CLNO               4.769e+01  9.823e+00   4.855 1.25e-06 ***
## M_CLNO                 2.680e+03  6.097e+02   4.395 1.14e-05 ***
## IMP_DEBTINC            1.098e+02  1.127e+01   9.744  < 2e-16 ***
## M_DEBTINC              6.320e+03  2.242e+02  28.190  < 2e-16 ***
## FLAG.Job.Other         4.791e+02  1.901e+02   2.520 0.011779 *
## FLAG.Job.Sales         2.842e+03  6.489e+02   4.379 1.22e-05 ***
## FLAG.Job.Self          2.064e+03  5.022e+02   4.109 4.05e-05 ***
## FLAG.Reason.HomeImp   -5.427e+02  1.976e+02  -2.746 0.006064 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5529 on 4120 degrees of freedom
## Multiple R-squared:  0.435,  Adjusted R-squared:  0.4321
## F-statistic:    151 on 21 and 4120 DF,  p-value: < 2.2e-16
```

```
plr = predict(lr_model1, data_test1)
head(plr)
```

```
##          4         6         7        15        17        18
## 11097.448 -2321.894 11008.296  5898.499 16905.210  1133.279
```

```
RMSElr = sqrt(mean((data_test1$TARGET_LOSS_AMT - plr)^2))
```

```
treeVars1 = t1E$variable.importance
treeVars1 = names(treeVars1)
treeVarsPlus1 = paste(treeVars1, collapse ="+")
F1 = as.formula(paste("TARGET_LOSS_AMT ~", treeVarsPlus1))
```

```
tree_LR1 = glm(F1, data=data_train1)
theLower_LR1 = lm(TARGET_LOSS_AMT ~ 1, data=data_train1)
```

```
summary(tree_LR1)
```

```
##
## Call:
## glm(formula = F1, data = data_train1)
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -5.873e+03  4.696e+02 -12.504  < 2e-16 ***
## M_DEBTINC    6.964e+03  2.248e+02  30.977  < 2e-16 ***
## IMP_DEBTINC  1.102e+02  1.130e+01   9.748  < 2e-16 ***
## IMP_DELINQ   1.723e+03  8.277e+01  20.813  < 2e-16 ***
## IMP_CLAGE   -1.043e+01  1.100e+00  -9.489  < 2e-16 ***
## LOAN         1.506e-01  8.321e-03  18.093  < 2e-16 ***
## M_VALUE      5.887e+03  6.472e+02   9.097  < 2e-16 ***
## IMP_VALUE    1.231e-02  2.590e-03   4.753 2.07e-06 ***
## IMP_MORTDUE -7.699e-03  3.418e-03  -2.252 0.024346 *
## IMP_CLNO     5.404e+01  9.685e+00   5.580 2.56e-08 ***
## IMP_YOJ     -4.872e+01  1.259e+01  -3.870 0.000111 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 32202311)
##
##     Null deviance: 2.2290e+11  on 4141  degrees of freedom
## Residual deviance: 1.3303e+11  on 4131  degrees of freedom
## AIC: 83372
##
## Number of Fisher Scoring iterations: 2
```

```
summary(theLower_LR1)
```

```
##
## Call:
## lm(formula = TARGET_LOSS_AMT ~ 1, data = data_train1)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -2726  -2726  -2726  -2726  76261
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)     2726        114   23.92   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7337 on 4141 degrees of freedom
```

```
lrt_model1 = stepAIC(theLower_LR1, direction = "both", scope = list(lower=theLower_LR1, upper=tree_LR1))
```

```
## Start:  AIC=73734.01
## TARGET_LOSS_AMT ~ 1
##
##                Df  Sum of Sq        RSS    AIC
## + M_DEBTINC     1 4.7153e+10 1.7575e+11 72752
## + IMP_DELINQ    1 2.9356e+10 1.9355e+11 73151
## + M_VALUE       1 1.0850e+10 2.1205e+11 73529
## + LOAN          1 9.4873e+09 2.1341e+11 73556
## + IMP_DEBTINC   1 7.7321e+09 2.1517e+11 73590
## + IMP_CLNO      1 3.7741e+09 2.1913e+11 73665
## + IMP_CLAGE     1 3.3814e+09 2.1952e+11 73673
## + IMP_VALUE     1 3.0724e+09 2.1983e+11 73679
## + IMP_MORTDUE   1 1.5436e+09 2.2136e+11 73707
## + IMP_YOJ       1 2.7913e+08 2.2262e+11 73731
## <none>                       2.2290e+11 73734
##
## Step:  AIC=72751.57
## TARGET_LOSS_AMT ~ M_DEBTINC
##
##                Df  Sum of Sq        RSS    AIC
## + IMP_DELINQ    1 1.6625e+10 1.5912e+11 72342
## + LOAN          1 1.4130e+10 1.6162e+11 72406
```

```
## + IMP_DEBTINC  1 5.6846e+09 1.7006e+11 72617
## + M_VALUE      1 4.4592e+09 1.7129e+11 72647
## + IMP_VALUE    1 4.4448e+09 1.7130e+11 72647
## + IMP_CLNO     1 3.5915e+09 1.7216e+11 72668
## + IMP_MORTDUE  1 2.7257e+09 1.7302e+11 72689
## + IMP_CLAGE    1 1.2992e+09 1.7445e+11 72723
## + IMP_YOJ      1 2.2179e+08 1.7553e+11 72748
## <none>                     1.7575e+11 72752
## - M_DEBTINC    1 4.7153e+10 2.2290e+11 73734
##
## Step:  AIC=72341.97
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ
##
##                Df  Sum of Sq        RSS    AIC
## + LOAN         1 1.4375e+10 1.4475e+11 71952
## + IMP_DEBTINC  1 5.2306e+09 1.5389e+11 72206
## + IMP_VALUE    1 4.7653e+09 1.5436e+11 72218
## + IMP_MORTDUE  1 2.6109e+09 1.5651e+11 72275
## + M_VALUE      1 2.5070e+09 1.5662e+11 72278
## + IMP_CLAGE    1 1.7654e+09 1.5736e+11 72298
## + IMP_CLNO     1 1.6652e+09 1.5746e+11 72300
## + IMP_YOJ      1 4.7816e+08 1.5865e+11 72332
## <none>                     1.5912e+11 72342
## - IMP_DELINQ   1 1.6625e+10 1.7575e+11 72752
## - M_DEBTINC    1 3.4422e+10 1.9355e+11 73151
##
## Step:  AIC=71951.81
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN
##
##                Df  Sum of Sq        RSS    AIC
## + IMP_DEBTINC  1 4.1659e+09 1.4058e+11 71833
## + IMP_CLAGE    1 2.7166e+09 1.4203e+11 71875
## + M_VALUE      1 2.3297e+09 1.4242e+11 71887
## + IMP_YOJ      1 1.1225e+09 1.4363e+11 71922
## + IMP_CLNO     1 1.0000e+09 1.4375e+11 71925
## + IMP_VALUE    1 9.9762e+08 1.4375e+11 71925
## + IMP_MORTDUE  1 6.9311e+08 1.4406e+11 71934
## <none>                     1.4475e+11 71952
## - LOAN         1 1.4375e+10 1.5912e+11 72342
## - IMP_DELINQ   1 1.6870e+10 1.6162e+11 72406
## - M_DEBTINC    1 3.8351e+10 1.8310e+11 72923
##
## Step:  AIC=71832.86
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC
##
##                Df  Sum of Sq        RSS    AIC
## + M_VALUE      1 2.5528e+09 1.3803e+11 71759
## + IMP_CLAGE    1 2.4359e+09 1.3815e+11 71762
## + IMP_YOJ      1 8.9256e+08 1.3969e+11 71808
## + IMP_VALUE    1 6.7675e+08 1.3991e+11 71815
## + IMP_CLNO     1 5.1313e+08 1.4007e+11 71820
## + IMP_MORTDUE  1 3.6240e+08 1.4022e+11 71824
## <none>                     1.4058e+11 71833
## - IMP_DEBTINC  1 4.1659e+09 1.4475e+11 71952
```

```
## - LOAN          1 1.3310e+10 1.5389e+11 72206
## - IMP_DELINQ     1 1.6450e+10 1.5703e+11 72289
## - M_DEBTINC      1 3.6770e+10 1.7735e+11 72793
##
## Step:  AIC=71758.95
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE
##
##                Df  Sum of Sq        RSS    AIC
## + IMP_CLAGE     1 2.3352e+09 1.3570e+11 71690
## + IMP_YOJ       1 8.8687e+08 1.3714e+11 71734
## + IMP_VALUE     1 7.4466e+08 1.3729e+11 71739
## + IMP_CLNO      1 5.8622e+08 1.3745e+11 71743
## + IMP_MORTDUE   1 3.3016e+08 1.3770e+11 71751
## <none>                      1.3803e+11 71759
## - M_VALUE       1 2.5528e+09 1.4058e+11 71833
## - IMP_DEBTINC   1 4.3890e+09 1.4242e+11 71887
## - LOAN          1 1.3105e+10 1.5114e+11 72133
## - IMP_DELINQ    1 1.4479e+10 1.5251e+11 72170
## - M_DEBTINC     1 3.3115e+10 1.7115e+11 72648
##
## Step:  AIC=71690.28
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE + IMP_CLAGE
##
##                Df  Sum of Sq        RSS    AIC
## + IMP_CLNO      1 1.3616e+09 1.3433e+11 71651
## + IMP_VALUE     1 1.2123e+09 1.3448e+11 71655
## + IMP_MORTDUE   1 5.5962e+08 1.3514e+11 71675
## + IMP_YOJ       1 4.7246e+08 1.3522e+11 71678
## <none>                      1.3570e+11 71690
## - IMP_CLAGE     1 2.3352e+09 1.3803e+11 71759
## - M_VALUE       1 2.4521e+09 1.3815e+11 71762
## - IMP_DEBTINC   1 4.1018e+09 1.3980e+11 71812
## - LOAN          1 1.3972e+10 1.4967e+11 72094
## - IMP_DELINQ    1 1.5032e+10 1.5073e+11 72123
## - M_DEBTINC     1 3.1160e+10 1.6686e+11 72544
##
## Step:  AIC=71650.51
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE + IMP_CLAGE + IMP_CLNO
##
##                Df  Sum of Sq        RSS    AIC
## + IMP_VALUE     1 7.2837e+08 1.3361e+11 71630
## + IMP_YOJ       1 4.6595e+08 1.3387e+11 71638
## + IMP_MORTDUE   1 1.7734e+08 1.3416e+11 71647
## <none>                      1.3433e+11 71651
## - IMP_CLNO      1 1.3616e+09 1.3570e+11 71690
## - M_VALUE       1 2.5480e+09 1.3688e+11 71726
## - IMP_CLAGE     1 3.1106e+09 1.3745e+11 71743
## - IMP_DEBTINC   1 3.3059e+09 1.3764e+11 71749
## - IMP_DELINQ    1 1.3432e+10 1.4777e+11 72043
## - LOAN          1 1.3507e+10 1.4784e+11 72045
## - M_DEBTINC     1 3.1140e+10 1.6547e+11 72512
```

```
## 
## Step:  AIC=71629.99
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE + IMP_CLAGE + IMP_CLNO + IMP_VALUE
## 
##               Df  Sum of Sq        RSS    AIC
## + IMP_YOJ      1 4.1518e+08 1.3319e+11 71619
## + IMP_MORTDUE  1 9.6294e+07 1.3351e+11 71629
## <none>                     1.3361e+11 71630
## - IMP_VALUE    1 7.2837e+08 1.3433e+11 71651
## - IMP_CLNO     1 8.7768e+08 1.3448e+11 71655
## - M_VALUE      1 2.5925e+09 1.3620e+11 71708
## - IMP_DEBTINC  1 3.1145e+09 1.3672e+11 71723
## - IMP_CLAGE    1 3.3650e+09 1.3697e+11 71731
## - LOAN         1 1.0411e+10 1.4402e+11 71939
## - IMP_DELINQ   1 1.3752e+10 1.4736e+11 72034
## - M_DEBTINC    1 3.1181e+10 1.6479e+11 72497
## 
## Step:  AIC=71619.1
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE + IMP_CLAGE + IMP_CLNO + IMP_VALUE + IMP_YOJ
## 
##               Df  Sum of Sq        RSS    AIC
## + IMP_MORTDUE  1 1.6338e+08 1.3303e+11 71616
## <none>                     1.3319e+11 71619
## - IMP_YOJ      1 4.1518e+08 1.3361e+11 71630
## - IMP_VALUE    1 6.7759e+08 1.3387e+11 71638
## - IMP_CLNO     1 8.8567e+08 1.3408e+11 71645
## - M_VALUE      1 2.5943e+09 1.3579e+11 71697
## - IMP_CLAGE    1 2.8747e+09 1.3607e+11 71706
## - IMP_DEBTINC  1 3.0040e+09 1.3620e+11 71709
## - LOAN         1 1.0716e+10 1.4391e+11 71938
## - IMP_DELINQ   1 1.3941e+10 1.4713e+11 72029
## - M_DEBTINC    1 3.1248e+10 1.6444e+11 72490
## 
## Step:  AIC=71616.01
## TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN + IMP_DEBTINC +
##     M_VALUE + IMP_CLAGE + IMP_CLNO + IMP_VALUE + IMP_YOJ + IMP_MORTDUE
## 
##               Df  Sum of Sq        RSS    AIC
## <none>                     1.3303e+11 71616
## - IMP_MORTDUE  1 1.6338e+08 1.3319e+11 71619
## - IMP_YOJ      1 4.8226e+08 1.3351e+11 71629
## - IMP_VALUE    1 7.2760e+08 1.3376e+11 71637
## - IMP_CLNO     1 1.0027e+09 1.3403e+11 71645
## - M_VALUE      1 2.6649e+09 1.3569e+11 71696
## - IMP_CLAGE    1 2.8996e+09 1.3593e+11 71703
## - IMP_DEBTINC  1 3.0601e+09 1.3609e+11 71708
## - LOAN         1 1.0542e+10 1.4357e+11 71930
## - IMP_DELINQ   1 1.3949e+10 1.4698e+11 72027
## - M_DEBTINC    1 3.0900e+10 1.6393e+11 72479
```

```r
summary(lrt_model1)
```

```
## 
## Call:
## lm(formula = TARGET_LOSS_AMT ~ M_DEBTINC + IMP_DELINQ + LOAN +
##     IMP_DEBTINC + M_VALUE + IMP_CLAGE + IMP_CLNO + IMP_VALUE +
##     IMP_YOJ + IMP_MORTDUE, data = data_train1)
## 
## Residuals:
##    Min    1Q Median    3Q    Max
## -28161  -2513   -439   1586  57349
## 
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -5.873e+03  4.696e+02 -12.504  < 2e-16 ***
## M_DEBTINC    6.964e+03  2.248e+02  30.977  < 2e-16 ***
## IMP_DELINQ   1.723e+03  8.277e+01  20.813  < 2e-16 ***
## LOAN         1.506e-01  8.321e-03  18.093  < 2e-16 ***
## IMP_DEBTINC  1.102e+02  1.130e+01   9.748  < 2e-16 ***
## M_VALUE      5.887e+03  6.472e+02   9.097  < 2e-16 ***
## IMP_CLAGE   -1.043e+01  1.100e+00  -9.489  < 2e-16 ***
## IMP_CLNO     5.404e+01  9.685e+00   5.580 2.56e-08 ***
## IMP_VALUE    1.231e-02  2.590e-03   4.753 2.07e-06 ***
## IMP_YOJ     -4.872e+01  1.259e+01  -3.870 0.000111 ***
## IMP_MORTDUE -7.699e-03  3.418e-03  -2.252 0.024346 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 5675 on 4131 degrees of freedom
## Multiple R-squared:  0.4032, Adjusted R-squared:  0.4018
## F-statistic: 279.1 on 10 and 4131 DF,  p-value: < 2.2e-16
```

```r
plr_tree1 = predict(tree_LR1, data_test1)
head(plr_tree1)
```

```
##         4         6         7        15        17        18
## 12303.995 -2330.417  8863.354  6664.713 15744.060  1735.312
```

```r
RMSElr_tree1 = sqrt(mean(data_test1$TARGET_LOSS_AMT - plr_tree1)^2)
```

```r
plr_tree1_step = predict(lrt_model1, data_test1)
head(plr_tree1_step)
```

```
##         4         6         7        15        17        18
## 12303.995 -2330.417  8863.354  6664.713 15744.060  1735.312
```

```r
RMSElr_tree1_step = sqrt(mean(data_test1$TARGET_LOSS_AMT - plr_tree1_step)^2)
```

```r
print(paste("TREE RMSE=", RMSEt))
```

```
## [1] "TREE RMSE= 0.638005314291569"
```

```r
print(paste("RF RMSE=", RMSEr))
```

```
## [1] "RF RMSE= 0.254043534143728"
```

```r
print(paste("GB RMSE=", RMSEg))
```

```
## [1] "GB RMSE= 3.12180712334603"
```

```r
print(paste("LR BACK RMSE=", RMSElr))
```

```
## [1] "LR BACK RMSE= 5340.94504235833"
```

```r
print(paste("LR TREE RMSE=", RMSElr_tree1))
```

```
## [1] "LR TREE RMSE= 4.85688854590777"
```

```r
print(paste("LR TREE STEP RMSE=", RMSElr_tree1_step))
```

```
## [1] "LR TREE STEP RMSE= 4.85688854590556"
```

The trees all are optimal According to the results of my code, random forest trees are better than remaining models, and random forest has the lowest value also and I recommend random forest.

```r
SEED=1
set.seed(SEED)
```

```r
data_flag= data
head(data_flag)
```

STEP-4

```
##   TARGET_BAD_FLAG TARGET_LOSS_AMT LOAN IMP_MORTDUE M_MORTDUE IMP_VALUE M_VALUE
## 1               1             641 1100       25860         0     39025       0
## 2               1            1109 1300       70053         0     68400       0
## 3               1             767 1500       13500         0     16700       0
## 4               1            1425 1500       65000         1     89000       1
## 5               0               0 1700       97800         0    112000       0
## 6               1             335 1700       30548         0     40320       0
##   IMP_YOJ M_YOJ IMP_DEROG M_DEROG IMP_DELINQ M_DELINQ IMP_CLAGE M_CLAGE
## 1    10.5     0         0       0          0        0  94.36667       0
## 2     7.0     0         0       0          2        0 121.83333       0
## 3     4.0     0         0       0          0        0 149.46667       0
## 4     7.0     1         1       1          1        1 174.00000       1
## 5     3.0     0         0       0          0        0  93.33333       0
```

```
## 6      9.0      0         0       0         0         0 101.46600         0
##    IMP_NINQ M_NINQ IMP_CLNO M_CLNO IMP_DEBTINC M_DEBTINC FLAG.Job.Mgr
## 1        1      0        9      0    35.00000         1            0
## 2        0      0       14      0    35.00000         1            0
## 3        1      0       10      0    35.00000         1            0
## 4        1      1       20      1    35.00000         1            0
## 5        0      0       14      0    35.00000         1            0
## 6        1      0        8      0    37.11361         0            0
##    FLAG.Job.Office FLAG.Job.Other FLAG.Job.ProfExe FLAG.Job.Sales FLAG.Job.Self
## 1               0              1                0              0             0
## 2               0              1                0              0             0
## 3               0              1                0              0             0
## 4               0              0                0              0             0
## 5               1              0                0              0             0
## 6               0              1                0              0             0
##    FLAG.Reason.DebtCon FLAG.Reason.HomeImp
## 1                   0                   1
## 2                   0                   1
## 3                   0                   1
## 4                   0                   0
## 5                   0                   1
## 6                   0                   1
```

```r
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.7,0.3))
data_train= data_flag[FLAG, ]
data_test= data_flag[! FLAG, ]
```

```r
dim(data_flag)
```

```
## [1] 5960    29
```

```r
dim(data_train)
```

```
## [1] 4142    29
```

```r
dim(data_test)
```

```
## [1] 1818    29
```

```r
theUpper_LR = glm(TARGET_BAD_FLAG ~ ., family = "binomial", data=data_train)
```

```
## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
theLower_LR = glm(TARGET_BAD_FLAG ~ 1, family = "binomial", data=data_train)
summary(theUpper_LR)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ ., family = "binomial", data = data_train)
##
## Coefficients:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)          -1.918e+01  1.416e+04  -0.001    0.999
## TARGET_LOSS_AMT       4.024e-02  1.653e+00   0.024    0.981
## LOAN                 -2.144e-03  3.050e-01  -0.007    0.994
## IMP_MORTDUE          -1.660e-05  1.406e-01   0.000    1.000
## M_MORTDUE            -5.263e+00  5.271e+03  -0.001    0.999
## IMP_VALUE            -2.348e-04  1.127e-01  -0.002    0.998
## M_VALUE               3.636e+01  2.317e+04   0.002    0.999
## IMP_YOJ               4.931e-01  3.034e+02   0.002    0.999
## M_YOJ                 5.084e+00  3.985e+03   0.001    0.999
## IMP_DEROG            -1.060e+00  2.004e+03  -0.001    1.000
## M_DEROG              -3.923e+00  1.323e+04   0.000    1.000
## IMP_DELINQ            1.022e+00  2.955e+03   0.000    1.000
## M_DELINQ             -2.669e+01  2.628e+04  -0.001    0.999
## IMP_CLAGE             1.777e-02  9.559e+00   0.002    0.999
## M_CLAGE               1.450e+01  8.849e+03   0.002    0.999
## IMP_NINQ             -1.966e-01  7.104e+02   0.000    1.000
## M_NINQ                1.935e+01  8.573e+03   0.002    0.998
## IMP_CLNO             -5.074e-01  1.850e+02  -0.003    0.998
## M_CLNO               -3.404e+00  1.103e+05   0.000    1.000
## IMP_DEBTINC           3.127e-01  1.898e+02   0.002    0.999
## M_DEBTINC            -6.578e+00  5.129e+03  -0.001    0.999
## FLAG.Job.Mgr          1.069e+01  1.491e+04   0.001    0.999
## FLAG.Job.Office       4.757e+00  1.327e+04   0.000    1.000
## FLAG.Job.Other        1.694e+01  1.259e+04   0.001    0.999
## FLAG.Job.ProfExe      1.183e+01  1.280e+04   0.001    0.999
## FLAG.Job.Sales       -6.669e+00  2.503e+04   0.000    1.000
## FLAG.Job.Self        -7.212e+01  8.520e+04  -0.001    0.999
## FLAG.Reason.DebtCon   2.604e-01  1.055e+04   0.000    1.000
## FLAG.Reason.HomeImp   2.930e+00  1.036e+04   0.000    1.000
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4.1553e+03  on 4141  degrees of freedom
## Residual deviance: 1.6318e-06  on 4113  degrees of freedom
## AIC: 58
##
## Number of Fisher Scoring iterations: 25
```

```r
summary(theLower_LR)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ 1, family = "binomial", data = data_train)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.38087    0.03878  -35.61   <2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 4155.3  on 4141  degrees of freedom
## AIC: 4157.3
##
## Number of Fisher Scoring iterations: 4
```

```r
lr_model = stepAIC(theLower_LR, direction="backward", scope=list(lower=theLower_LR, upper=theUpper_LR))
```

```
## Start:  AIC=4157.3
## TARGET_BAD_FLAG ~ 1
```

```r
summary(lr_model)
```

```
##
## Call:
## glm(formula = TARGET_BAD_FLAG ~ 1, family = "binomial", data = data_train)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.38087    0.03878  -35.61   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 4155.3  on 4141  degrees of freedom
## Residual deviance: 4155.3  on 4141  degrees of freedom
## AIC: 4157.3
##
## Number of Fisher Scoring iterations: 4
```

```r
predicted_bad_flag <- predict(theLower_LR, data = data_test, type = "response")
```

```r
loss_data = data_train[data_train$TARGET_BAD_FLAG == 1, ]
loss_model = lm(TARGET_LOSS_AMT ~ ., data = loss_data)
```

```r
loss_var_importance <- summary(loss_model)$coefficients
print(loss_var_importance)
```

```
##                   Estimate    Std. Error     t value      Pr(>|t|)
## (Intercept)  -1.017382e+04 1.244452e+03  -8.1753432 1.145102e-15
## LOAN          7.859490e-01 1.352835e-02  58.0964347 5.359289e-290
## IMP_MORTDUE   6.793954e-03 3.921970e-03   1.7322809 8.360706e-02
## M_MORTDUE    -9.342189e+02 5.187011e+02  -1.8010735 7.206589e-02
## IMP_VALUE    -8.447077e-03 2.512778e-03  -3.3616487 8.113745e-04
## M_VALUE      -6.340333e+01 4.787496e+02  -0.1324353 8.946732e-01
## IMP_YOJ      -1.187469e+02 1.916795e+01  -6.1950761 9.293062e-10
```

```
## M_YOJ                1.263856e+02 6.823336e+02    0.1852255  8.530989e-01
## IMP_DEROG             2.594085e+02 9.638556e+01    2.6913624  7.263931e-03
## M_DEROG               1.431950e+03 8.323868e+02    1.7202942  8.576376e-02
## IMP_DELINQ            7.727642e+02 7.333726e+01   10.5371287  2.084856e-24
## M_DELINQ             -6.875716e+02 1.054520e+03   -0.6520235  5.145723e-01
## IMP_CLAGE            -1.906777e+01 1.567114e+00  -12.1674422  2.201666e-31
## M_CLAGE              -5.240999e+03 1.061791e+03   -4.9359982  9.697194e-07
## IMP_NINQ             -4.680167e+01 6.255860e+01   -0.7481253  4.546034e-01
## M_NINQ                3.154285e+02 1.034544e+03    0.3048962  7.605241e-01
## IMP_CLNO              1.993446e+02 1.317549e+01   15.1299623  1.079791e-45
## M_CLNO                5.237962e+03 1.956065e+03    2.6778050  7.561822e-03
## IMP_DEBTINC           1.081355e+02 1.158078e+01    9.3375028  9.422584e-20
## M_DEBTINC             5.531931e+03 2.849193e+02   19.4157820  3.702757e-69
## FLAG.Job.Mgr         -5.435149e+02 1.064359e+03   -0.5106498  6.097364e-01
## FLAG.Job.Office      -9.322227e+02 1.087681e+03   -0.8570737  3.916595e-01
## FLAG.Job.Other       -4.319012e+02 1.016179e+03   -0.4250245  6.709325e-01
## FLAG.Job.ProfExe     -9.762192e+02 1.061567e+03   -0.9196021  3.580565e-01
## FLAG.Job.Sales        7.600560e+02 1.249418e+03    0.6083280  5.431417e-01
## FLAG.Job.Self         1.425411e+03 1.171145e+03    1.2171094  2.239197e-01
## FLAG.Reason.DebtCon   2.772750e+03 6.871799e+02    4.0349692  5.982065e-05
## FLAG.Reason.HomeImp   1.247097e+03 7.142154e+02    1.7461077  8.117416e-02
```

```r
predicted_loss <- predict(loss_model, data = data_test)
```

```r
probability_severity <- predicted_bad_flag * predicted_loss
```

```
## Warning in predicted_bad_flag * predicted_loss: longer object length is not a
## multiple of shorter object length
```

```r
rmse <- sqrt(mean((probability_severity - data_test$TARGET_LOSS_AMT)^2))
```

```
## Warning in probability_severity - data_test$TARGET_LOSS_AMT: longer object
## length is not a multiple of shorter object length
```

```r
print(paste("RMSE for Probability / Severity model:", rmse))
```

```
## [1] "RMSE for Probability / Severity model: 6922.3744547304"
```

The decision trees are optimal because it is easy to understand. I recommend random forest because it's decision trees are very easy to understand and it's classifies everything clearly.