

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

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

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

```
library(gbm)
```

```
## Loaded gbm 2.1.9
```

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

```
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_DELIQ : int 0 2 0 1 0 0 2 0 2 0 ...
## $ M_DELIQ : 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_DELIQ M_DELIQ 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_DELIQ	M_DELIQ	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
```

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

```
dim(data_train)
```

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

```
dim(data_test)
```

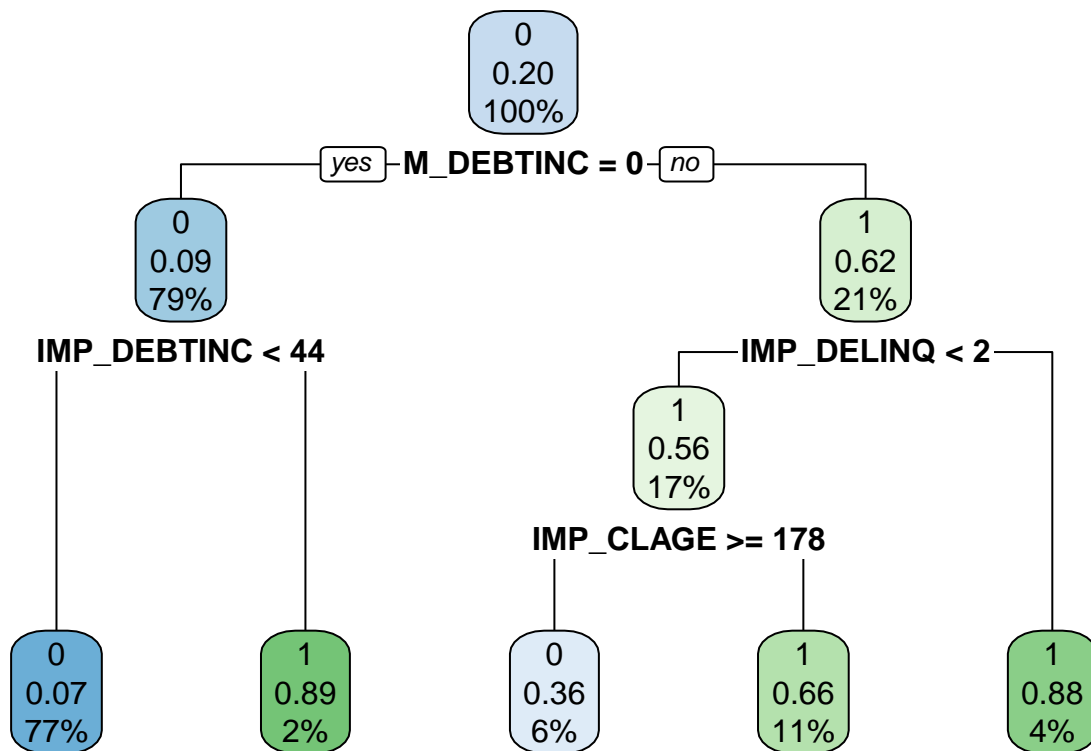
```
## [1] 1818 28
```

## 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")
```

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

## RF

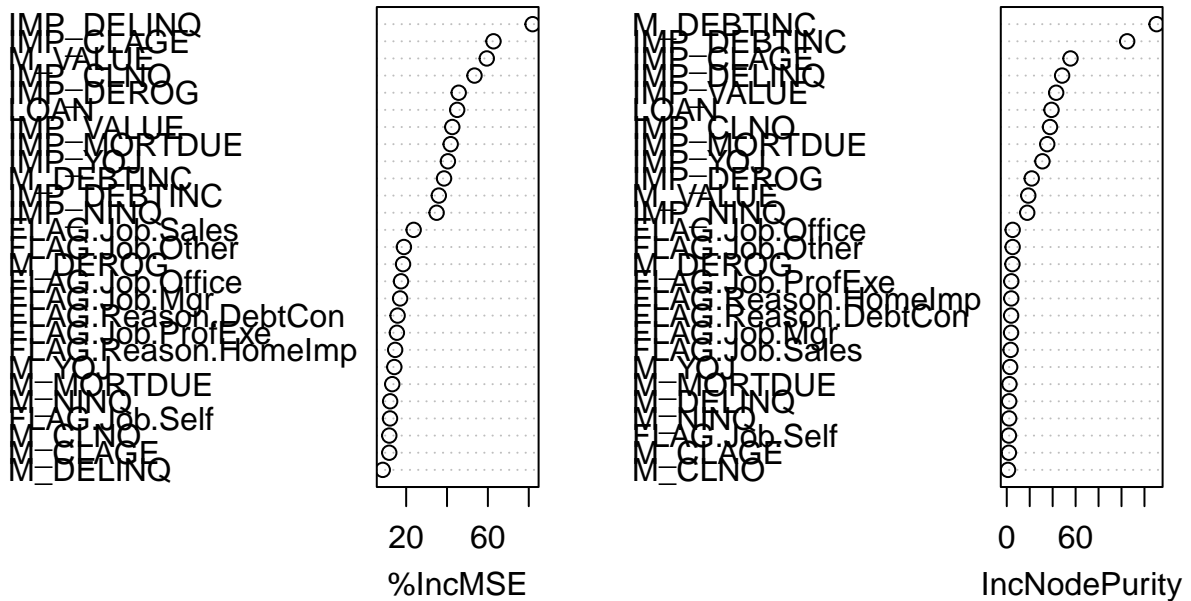
```
## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values. Are you sure you want to do regression?
```

```
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
```

```
varImpPlot(rf_model)
```

rf\_model

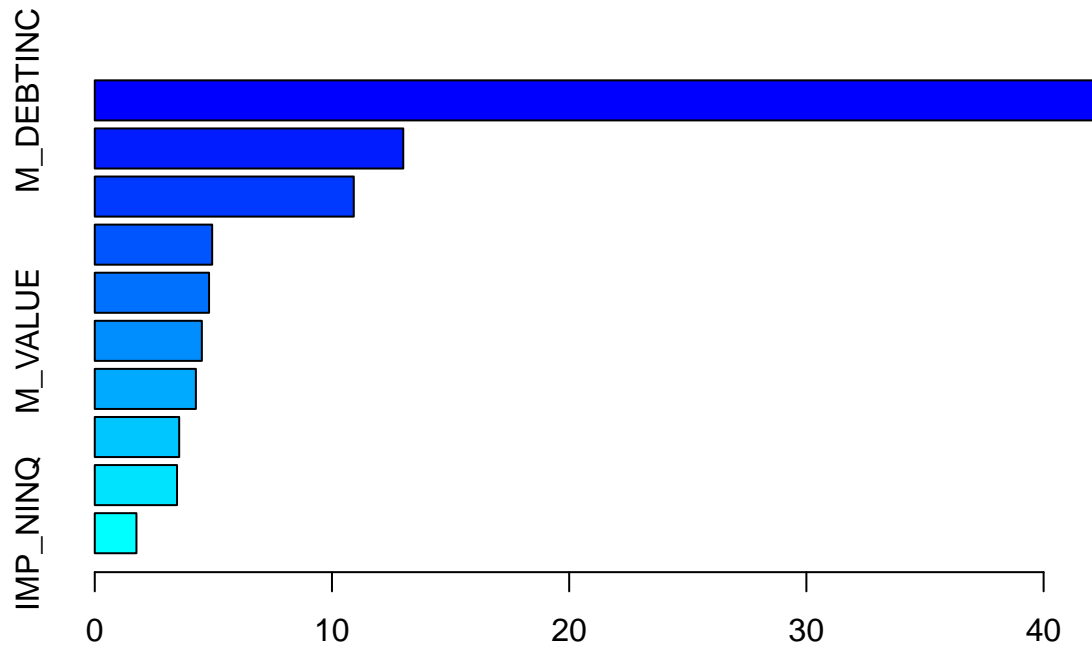


```
pr= predict(rf_model, data_test)
head(pr)
```

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

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

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



Relative influence

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
```

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

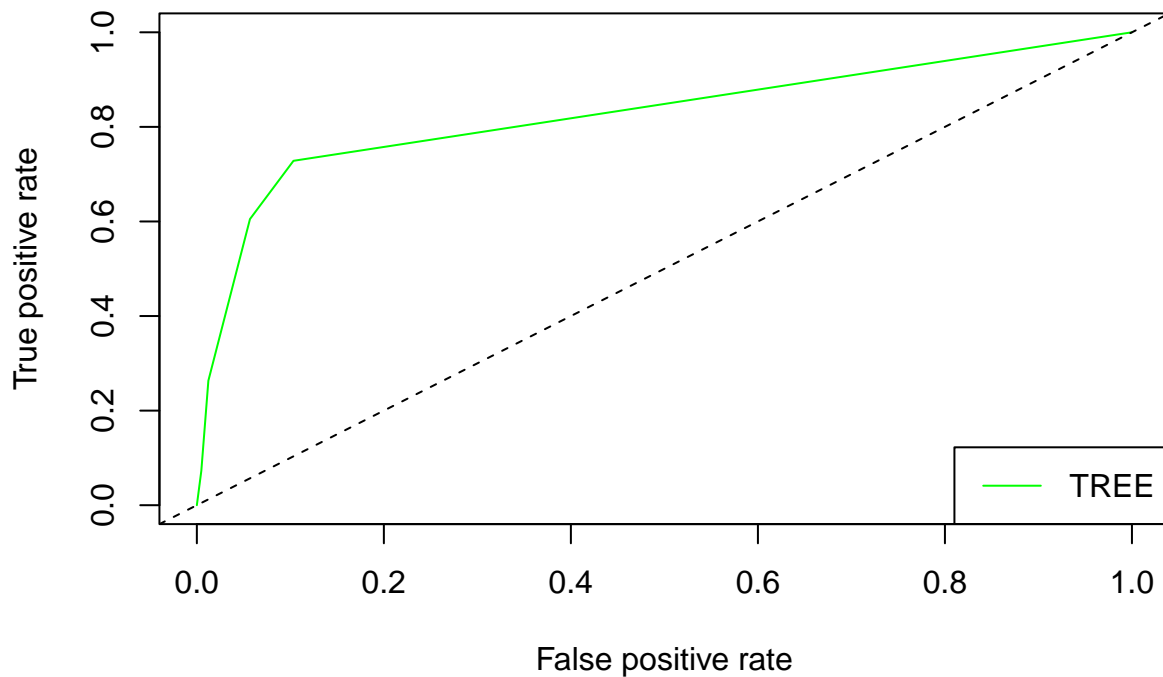
```
## Using 500 trees...
```

```
head(pg)
```

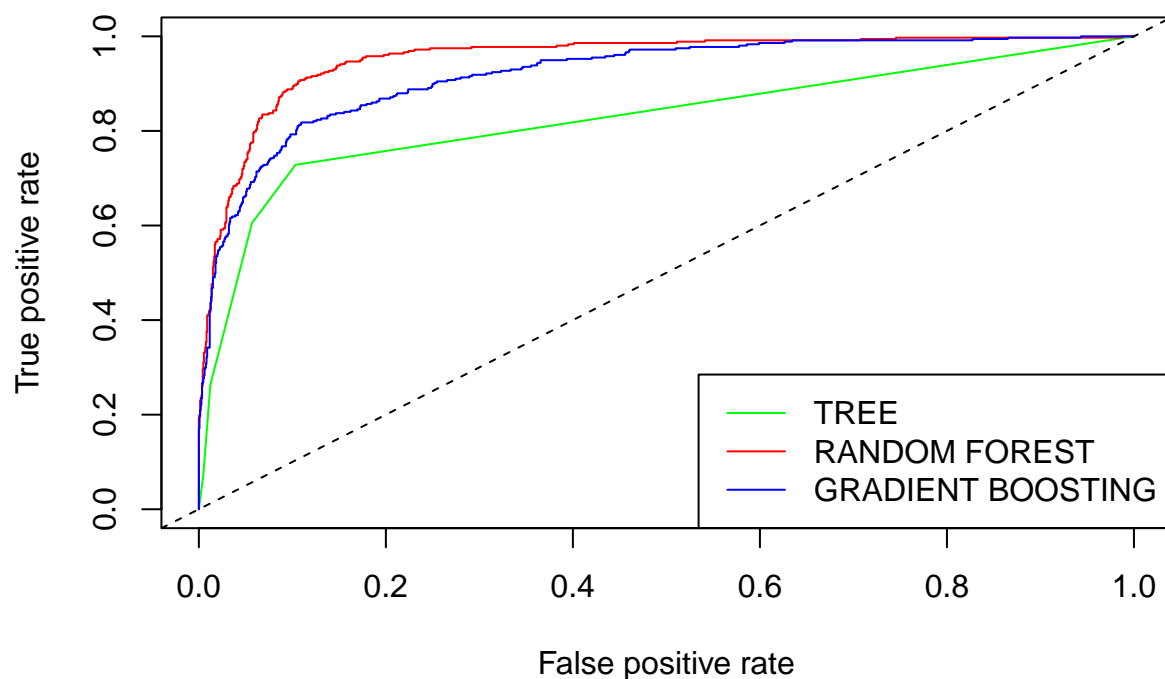
```
## [1] 0.9666599 0.4323602 0.9940194 0.8066121 0.9980174 0.9721196
```

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

```
plot(pt3, col= "green")
abline(0,1,lty=2)
legend("bottomright", c("TREE"), col=c("green"), bty="y", lty=1)
```



```
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"), bty="n", lty=1)
```



```
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"
```

```
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.6,0.4))
data_train= data_flag[FLAG, ]
data_test= data_flag[! FLAG, ]
```

```
dim(data_flag)
```

```
2
```

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

```
dim(data_train)
```

```
## [1] 3558 28
```

```
dim(data_test)
```

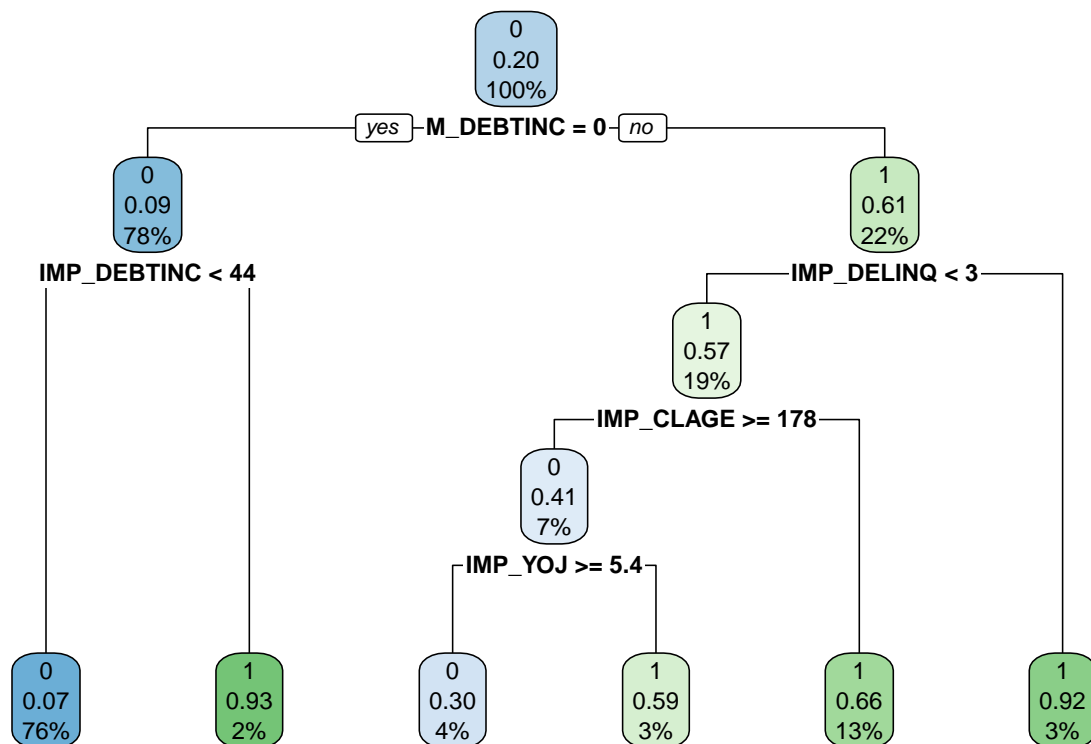
```
## [1] 2402 28
```

## 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      LOAN  IMP_CLAGE      M_VALUE
## 451.4798311 129.3026913  34.7603496  24.7719074  18.6218294  17.9895563
##      IMP_DEROG      IMP_YOJ  IMP_VALUE  IMP_CLNO IMP_MORTDUE
## 12.1412396 12.0441074  6.3717914  1.8108232  0.7885382
```

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

```
##           0           1
## 1  0.34375000 0.65625000
## 2  0.34375000 0.65625000
## 4  0.34375000 0.65625000
## 8  0.93235294 0.06764706
## 11 0.34375000 0.65625000
## 17 0.07692308 0.92307692
```

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

```
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?
```

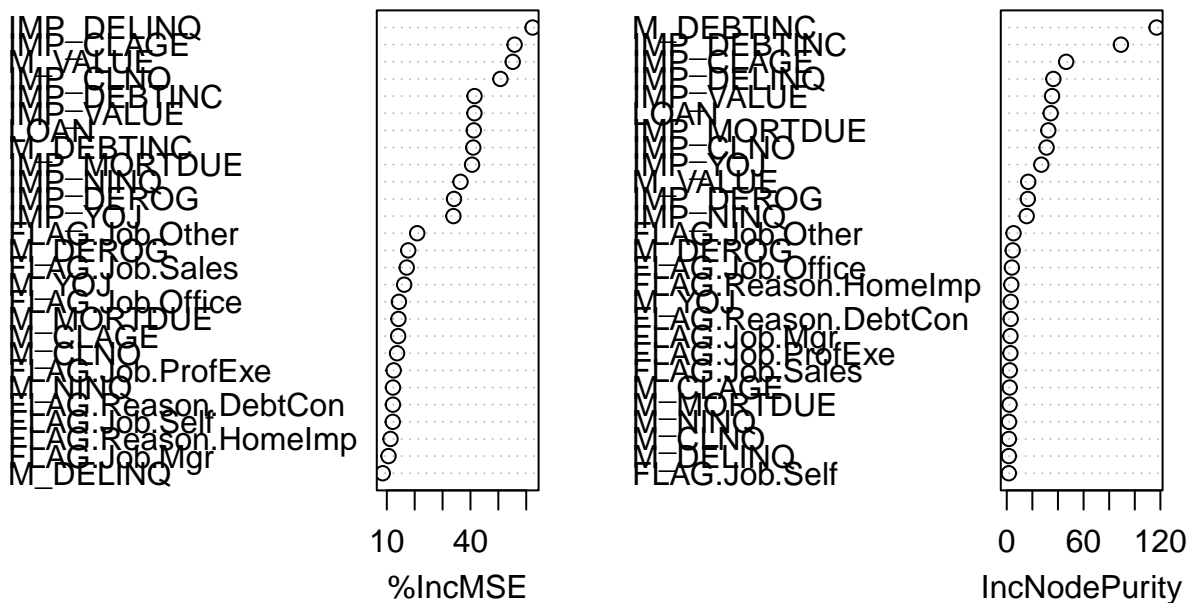
```
importance(rf_model)
```

```
##           %IncMSE IncNodePurity
## LOAN           41.194806      34.297124
## IMP_MORTDUE      40.572104      32.442165
## M_MORTDUE        14.173160       2.178831
## IMP_VALUE        41.420248      35.412119
## M_VALUE          55.159900      16.761763
## IMP_YOJ          33.882859      26.985759
## M_YOJ            16.225514       3.104356
## IMP_DEROG        34.097784      16.419615
## M_DEROG          17.682940       4.646590
## IMP_DELINQ       62.287075      36.397837
## M_DELINQ         8.551376       1.623851
## IMP_CLAGE        55.830205      46.401715
## M_CLAGE          14.073023       2.303335
## IMP_NINQ         36.423910      15.548880
## M_NINQ           12.213108       1.794180
## IMP_CLNO         50.736179      31.123985
## M_CLNO           13.673396       1.687058
```

```
## IMP_DEBTINC      41.454909      89.175332
## M_DEBTINC        41.003441     117.053819
## FLAG.Job.Mgr      10.603971       2.879416
## FLAG.Job.Office   14.340960       3.987755
## FLAG.Job.Other     20.905949       5.278955
## FLAG.Job.ProfExe   12.457021       2.836592
## FLAG.Job.Sales     17.142257       2.396901
## FLAG.Job.Self      12.135615       1.606758
## FLAG.Reason.DebtCon 12.188164       3.066308
## FLAG.Reason.HomeImp 11.325769       3.551200
```

```
varImpPlot(rf_model)
```

rf\_model

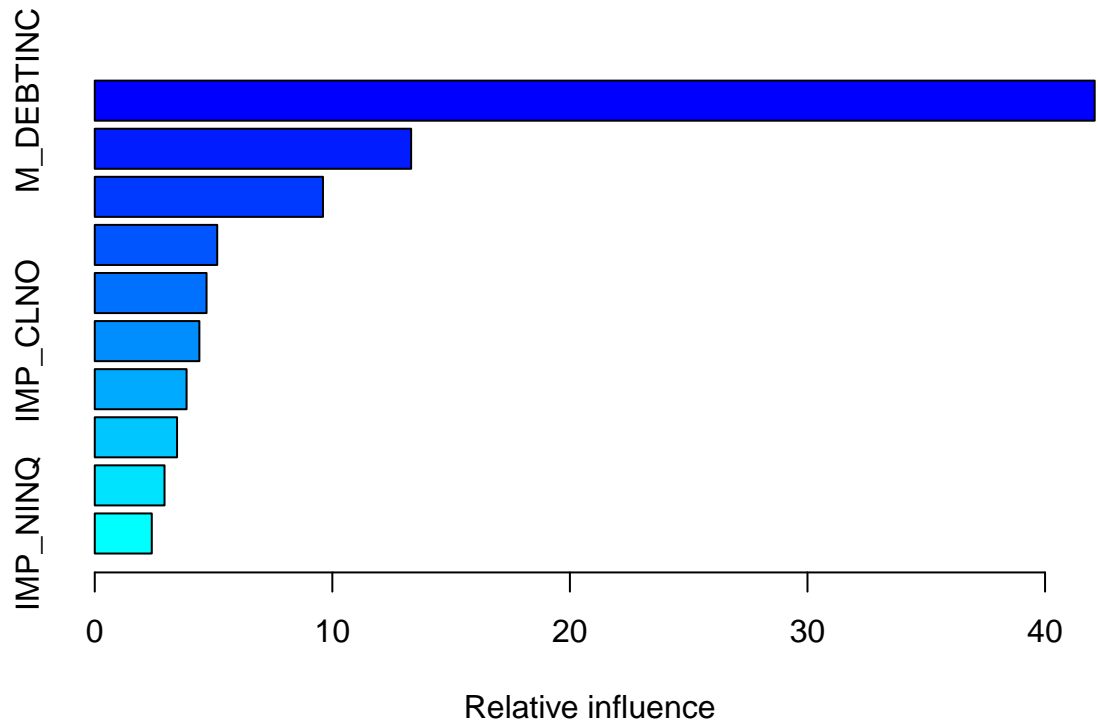


```
pr= predict(rf_model, data_test)
head(pr)
```

```
##          1          2          4          8         11         17
## 0.8561333 0.7809667 0.4428619 0.7999476 0.7958286 0.9074000
```

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

```
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	42.0885985
## IMP_DEBTINC	IMP_DEBTINC	13.3167155
## IMP_DELINQ	IMP_DELINQ	9.6058058
## IMP_CLAGE	IMP_CLAGE	5.1540758
## M_VALUE	M_VALUE	4.7051107
## IMP_CLNO	IMP_CLNO	4.4031885
## LOAN	LOAN	3.8644231
## IMP_VALUE	IMP_VALUE	3.4634952
## IMP_DEROG	IMP_DEROG	2.9364220
## IMP_NINQ	IMP_NINQ	2.3993405
## IMP_MORTDUE	IMP_MORTDUE	2.0967857
## M_DEROG	M_DEROG	1.4931345
## IMP_YOJ	IMP_YOJ	1.4070347
## M_CLNO	M_CLNO	0.9857387
## FLAG.Job.Sales	FLAG.Job.Sales	0.7323381
## FLAG.Job.Other	FLAG.Job.Other	0.4201364
## M_YOJ	M_YOJ	0.2612819
## FLAG.Job.Office	FLAG.Job.Office	0.1738503
## M_CLAGE	M_CLAGE	0.1579454

```
## M_DELINQ                M_DELINQ  0.1518222
## FLAG.Reason.DebtCon FLAG.Reason.DebtCon  0.1062654
## FLAG.Job.Mgr          FLAG.Job.Mgr  0.0764912
## M_MORTDUE             M_MORTDUE  0.0000000
## M_NINQ                M_NINQ  0.0000000
## FLAG.Job.ProfExe      FLAG.Job.ProfExe  0.0000000
## FLAG.Job.Self        FLAG.Job.Self  0.0000000
## FLAG.Reason.HomeImp FLAG.Reason.HomeImp  0.0000000
```

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

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

```
head(pg)
```

```
## [1] 0.8961460 0.8881884 0.9707546 0.3946920 0.9904425 0.9944415
```

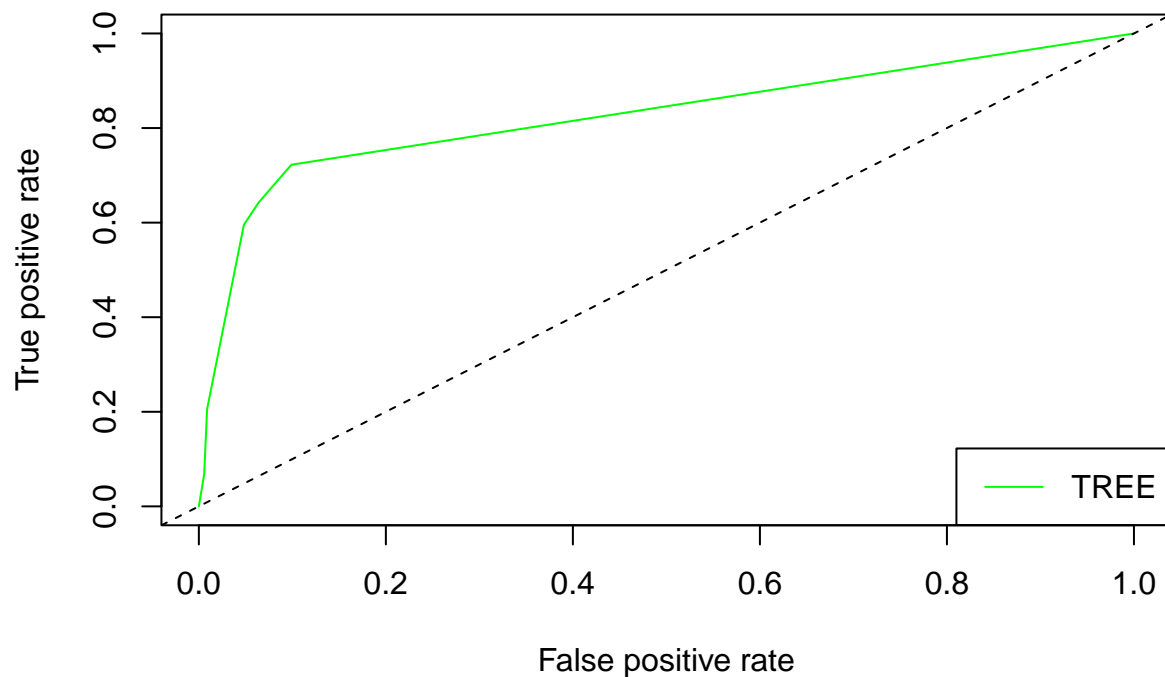
```
pg2=prediction(pg, data_test$TARGET_BAD_FLAG)
```

```
pg3 = performance(pg2, "tpr", "fpr")
```

```
plot(pt3, col= "green")
```

```
abline(0,1,lty=2)
```

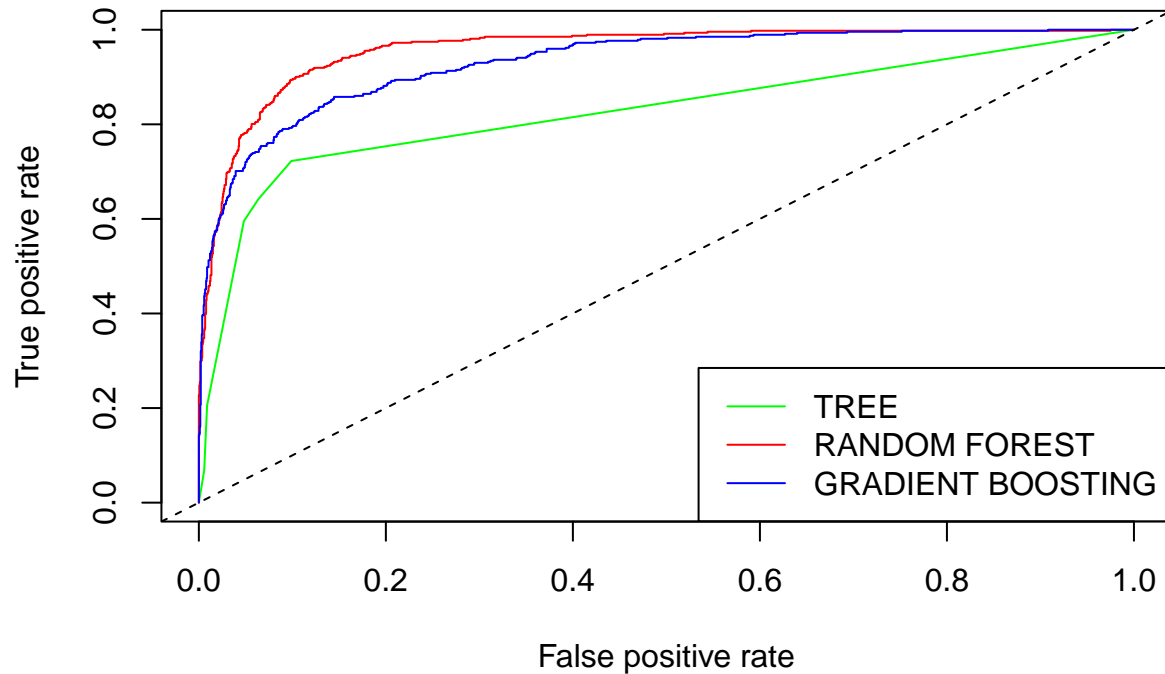
```
legend("bottomright", c("TREE"), col=c("green"), bty="y", lty=1)
```



```

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= 0.826036818301572"

```

```

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

```

```

## [1] "RF AUC 0.958854944234619"

```

```

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

```

```

## [1] "GB AUC 0.931909194695691"

```



```
FLAG= sample(c(TRUE,FALSE), nrow(data_flag), replace=TRUE, prob=c(0.8,0.2))
data_train= data_flag[FLAG, ]
data_test= data_flag[! FLAG, ]
```

```
dim(data_flag)
```

```
3
```

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

```
dim(data_train)
```

```
## [1] 4792 28
```

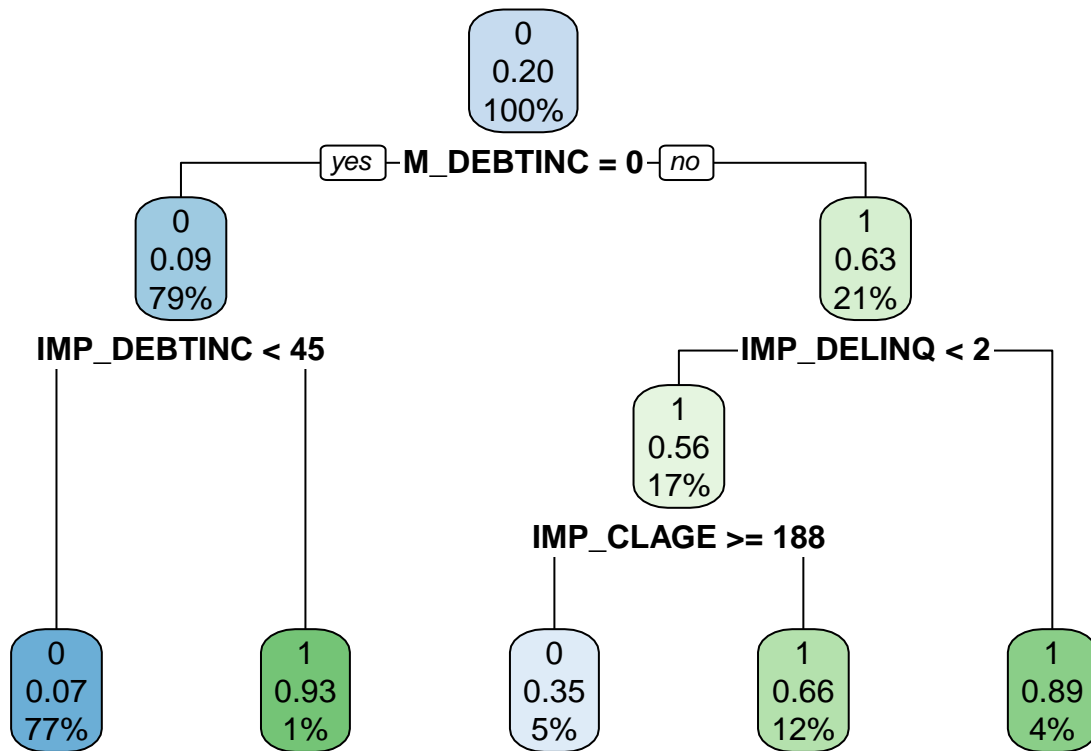
```
dim(data_test)
```

```
## [1] 1168 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
## 626.3370923 142.7025290 61.9703529 34.5753403 23.8779537 23.2656984
##      IMP_DEROG IMP_MORTDUE      IMP_YOJ      IMP_CLNO      IMP_VALUE
## 11.2875850 8.0145403 3.0111422 1.0829500 0.8009731
```

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

```
##           0           1
## 5  0.3392857 0.66071429
## 11 0.3392857 0.66071429
## 16 0.6486486 0.35135135
## 18 0.9289381 0.07106188
## 22 0.3392857 0.66071429
## 35 0.9289381 0.07106188
```

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

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

## RF

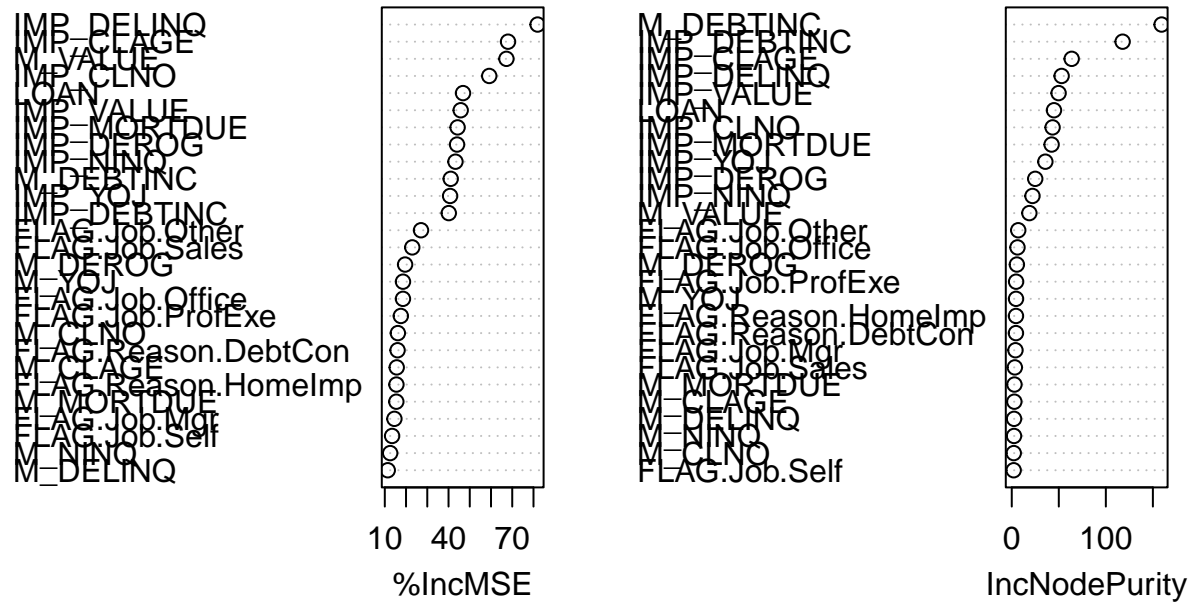
```
## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values. Are you sure you want to do regression?
```

```
importance(rf_model)
```

##	%IncMSE	IncNodePurity
## LOAN	46.81960	44.853496
## IMP_MORTDUE	44.27769	42.350823
## M_MORTDUE	15.43293	2.863397
## IMP_VALUE	45.73213	49.787657
## M_VALUE	67.26109	18.698896
## IMP_YOJ	40.74385	35.698081
## M_YOJ	18.56391	4.532580
## IMP_DEROG	44.01648	24.932666
## M_DEROG	19.55296	5.442396
## IMP_DELINQ	81.93491	52.995252
## M_DELINQ	11.40273	2.438143
## IMP_CLAGE	68.01695	63.685696
## M_CLAGE	15.61967	2.730553
## IMP_NINQ	43.26564	22.009776
## M_NINQ	12.53876	2.404666
## IMP_CLNO	59.16931	43.392875
## M_CLNO	16.15203	2.101999
## IMP_DEBTINC	40.12370	117.825034
## M_DEBTINC	41.03456	159.265833
## FLAG.Job.Mgr	14.52236	3.920975
## FLAG.Job.Office	18.55626	6.085865
## FLAG.Job.Other	27.05262	6.882150
## FLAG.Job.ProfExe	17.55373	4.614041
## FLAG.Job.Sales	22.92799	3.250753
## FLAG.Job.Self	13.44711	2.025779
## FLAG.Reason.DebtCon	16.01982	4.427095
## FLAG.Reason.HomeImp	15.47547	4.454954

```
varImpPlot(rf_model)
```

## rf\_model

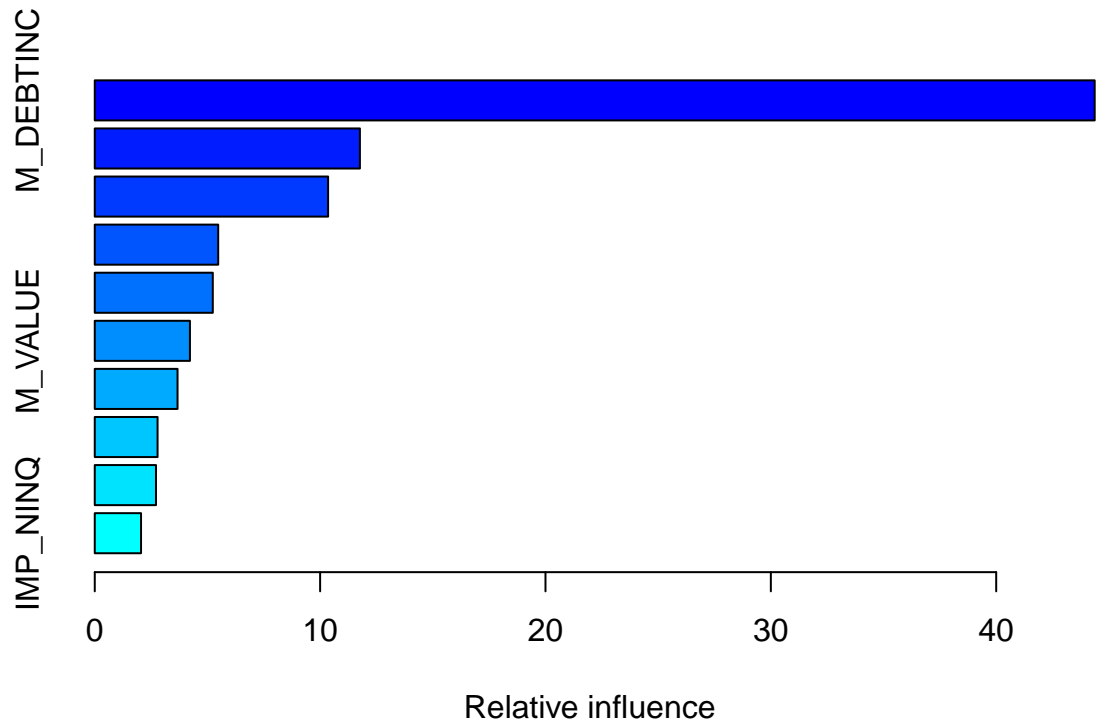


```
pr= predict(rf_model, data_test)
head(pr)
```

##	5	11	16	18	22	35
##	0.59647037	0.84863333	0.68320000	0.44063333	0.72902157	0.07936667

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

```
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	44.36924397
## IMP_DEBTINC	IMP_DEBTINC	11.76557379
## IMP_DELINQ	IMP_DELINQ	10.35354146
## IMP_CLAGE	IMP_CLAGE	5.47722691
## IMP_VALUE	IMP_VALUE	5.23702585
## M_VALUE	M_VALUE	4.22264294
## IMP_DEROG	IMP_DEROG	3.67235549
## IMP_CLNO	IMP_CLNO	2.78658182
## LOAN	LOAN	2.71628254
## IMP_NINQ	IMP_NINQ	2.05292270
## IMP_MORTDUE	IMP_MORTDUE	1.89854729
## M_DEROG	M_DEROG	1.56121705
## IMP_YOJ	IMP_YOJ	1.03444965
## M_CLNO	M_CLNO	0.95867113
## FLAG.Job.Sales	FLAG.Job.Sales	0.65428911
## FLAG.Job.Other	FLAG.Job.Other	0.59912332
## M_YOJ	M_YOJ	0.29359492
## FLAG.Job.Office	FLAG.Job.Office	0.21980790
## M_DELINQ	M_DELINQ	0.05539072
## FLAG.Job.Self	FLAG.Job.Self	0.03917480
## FLAG.Job.ProfExe	FLAG.Job.ProfExe	0.03233662
## M_MORTDUE	M_MORTDUE	0.00000000
## M_CLAGE	M_CLAGE	0.00000000
## M_NINQ	M_NINQ	0.00000000
## FLAG.Job.Mgr	FLAG.Job.Mgr	0.00000000

```
## FLAG.Reason.DebtCon FLAG.Reason.DebtCon 0.00000000
## FLAG.Reason.HomeImp FLAG.Reason.HomeImp 0.00000000
```

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

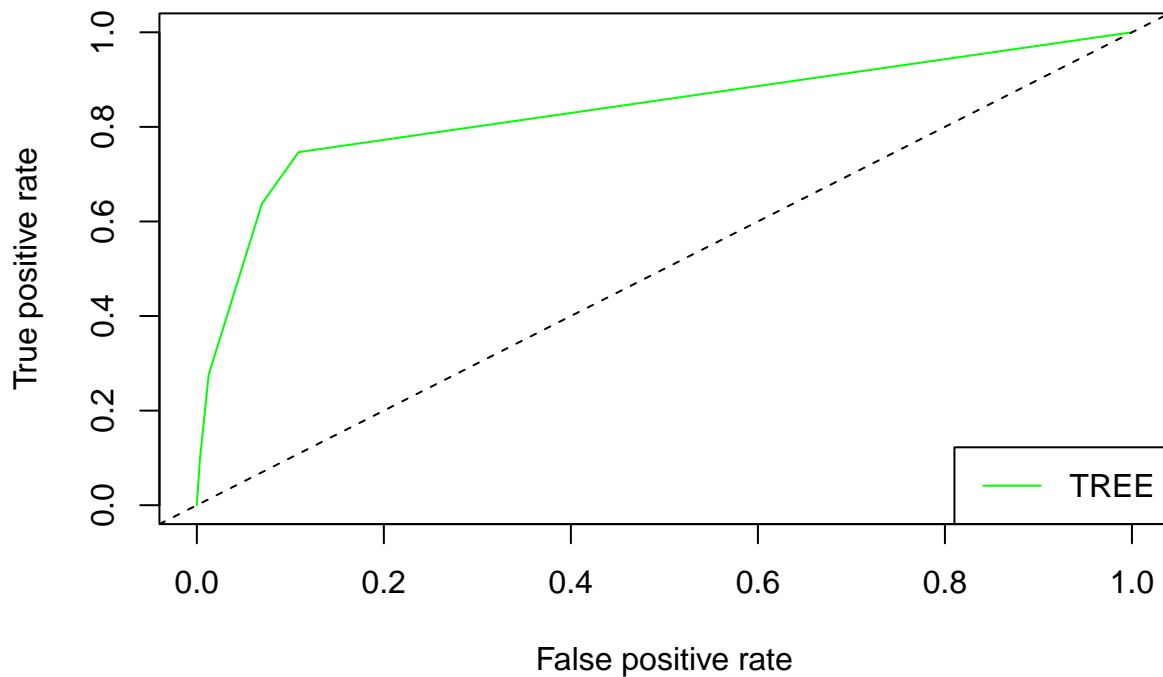
```
## Using 500 trees...
```

```
head(pg)
```

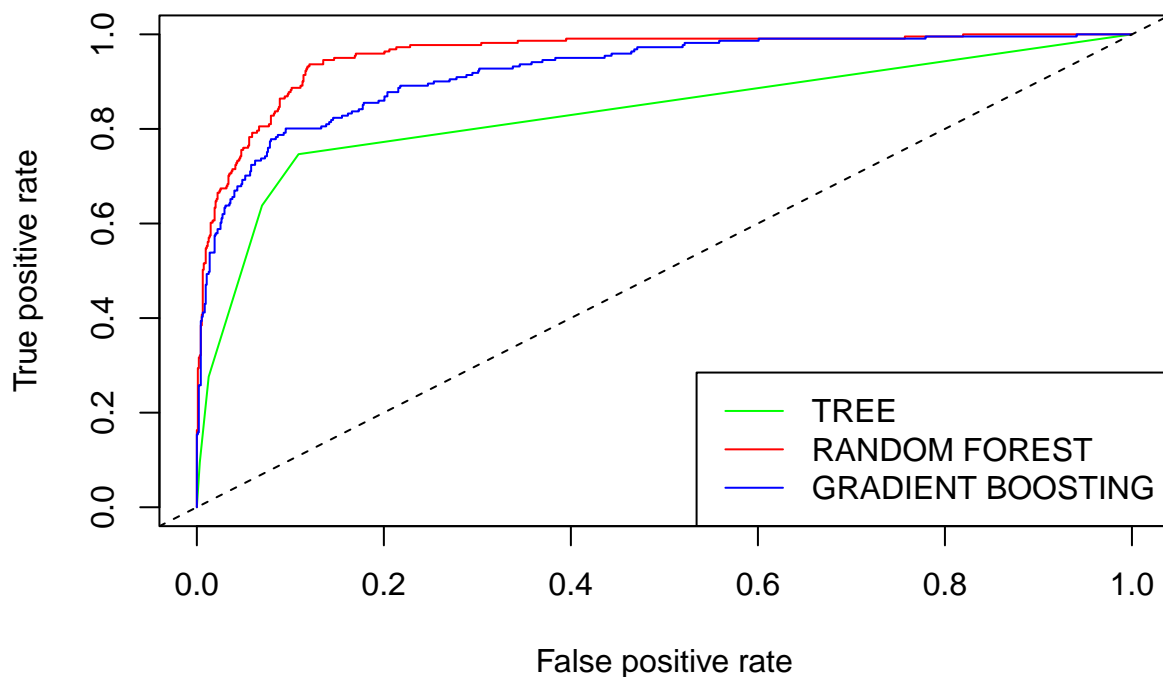
```
## [1] 0.7404080 0.9927654 0.8081808 0.9565759 0.9394374 0.1101637
```

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

```
plot(pt3, col= "green")
abline(0,1,lty=2)
legend("bottomright", c("TREE"), col=c("green"), bty="y", lty=1)
```



```
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"), bty="n", lty=1)
```



```
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= 0.833341296879405"
```

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

```
## [1] "RF AUC 0.958067151805902"
```

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

```
## [1] "GB AUC 0.922967026141147"
```

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

```
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_DELIQ M_DELIQ 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_amt), replace=TRUE, prob=c(0.7,0.3))
data_train_s3=data_amt[FLAG, ]
data_test_s3=data_amt[! FLAG, ]
```

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

```
1
```

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



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

```
## [1] 2731.162
```

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

```
## [1] 2550.459
```

```
dim(data_amt)
```

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

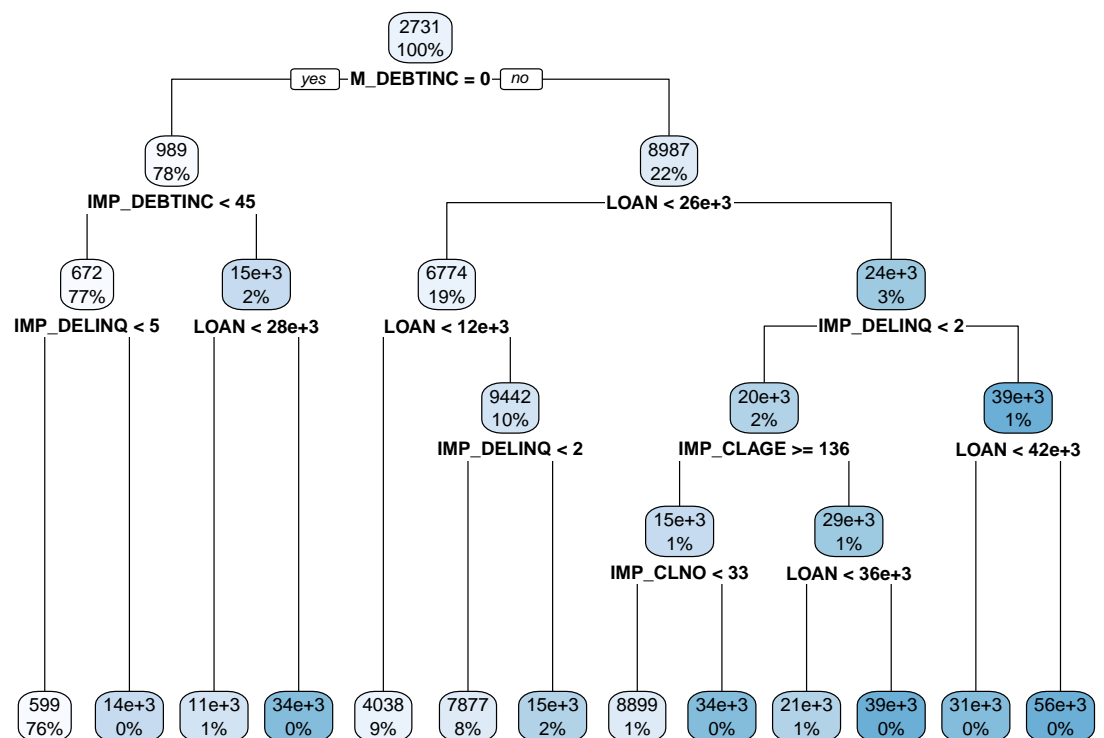
```
dim(data_train_s3)
```

```
## [1] 4146 28
```

```
dim(data_test_s3)
```

```
## [1] 1814 28
```

```
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
##    49810902538      45185875053      14741529346      14221900743
##          IMP_CLNO          IMP_VALUE      IMP_MORTDUE      IMP_CLAGE
##    9833481005      8244362057      5765237698      5428907980
##          M_VALUE FLAG.Reason.HomeImp FLAG.Reason.DebtCon      IMP_DEROG
##    2558517291      2171987090      1700509878      1506618957
##          IMP_YOJ      FLAG.Job.Self      M_YOJ      IMP_NINQ
##    1036505358      919586372      407588199      338896802
```

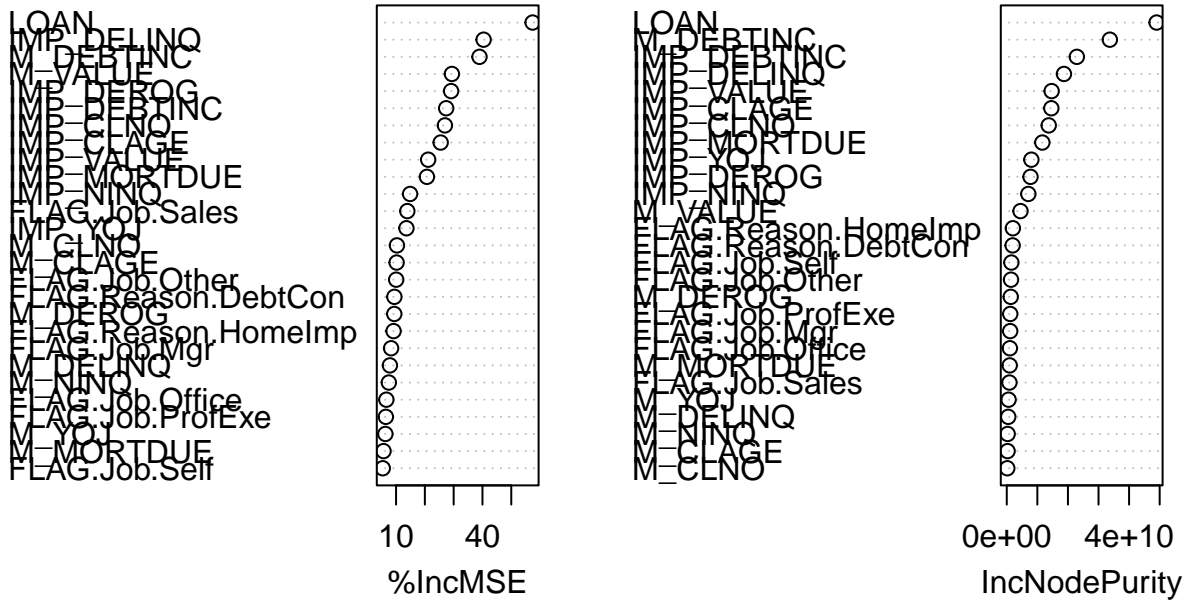
```
rf_model_s3 = randomForest(data = data_train_s3, TARGET_LOSS_AMT ~., ntree=500, importance= TRUE)
importance(rf_model_s3)
```

## RF

```
##          %IncMSE IncNodePurity
## LOAN          57.413192      48999229003
## IMP_MORTDUE    20.714794      11630061454
## M_MORTDUE      5.640009      965249710
## IMP_VALUE     21.148383      14671077674
## M_VALUE       29.385768      4495555210
## IMP_YOJ       13.602251      8043470072
## M_YOJ         6.285305      595212679
## IMP_DEROG     29.109460      7769363985
## M_DEROG       9.371492      1293547441
## IMP_DELINQ    40.398351      18700989627
## M_DELINQ      7.860615      484590970
## IMP_CLAGE     25.485598      14572470692
## M_CLAGE       10.188013      263070036
## IMP_NINQ      14.866642      7055757983
## M_NINQ        7.490540      290039569
## IMP_CLNO      26.964581      13722185416
## M_CLNO        10.304798      173527540
## IMP_DEBTINC   27.402913      22916284912
## M_DEBTINC     38.970907      33710722564
## FLAG.Job.Mgr   8.274245      1117785020
## FLAG.Job.Office 6.627984      1018069335
## FLAG.Job.Other 10.045067      1395048079
## FLAG.Job.ProfExe 6.446398      1140169738
## FLAG.Job.Sales 13.908192      876758471
## FLAG.Job.Self  5.378618      1504454543
## FLAG.Reason.DebtCon 9.405418      1915371613
## FLAG.Reason.HomeImp 9.126647      1997875295
```

```
varImpPlot(rf_model_s3)
```

## rf\_model\_s3

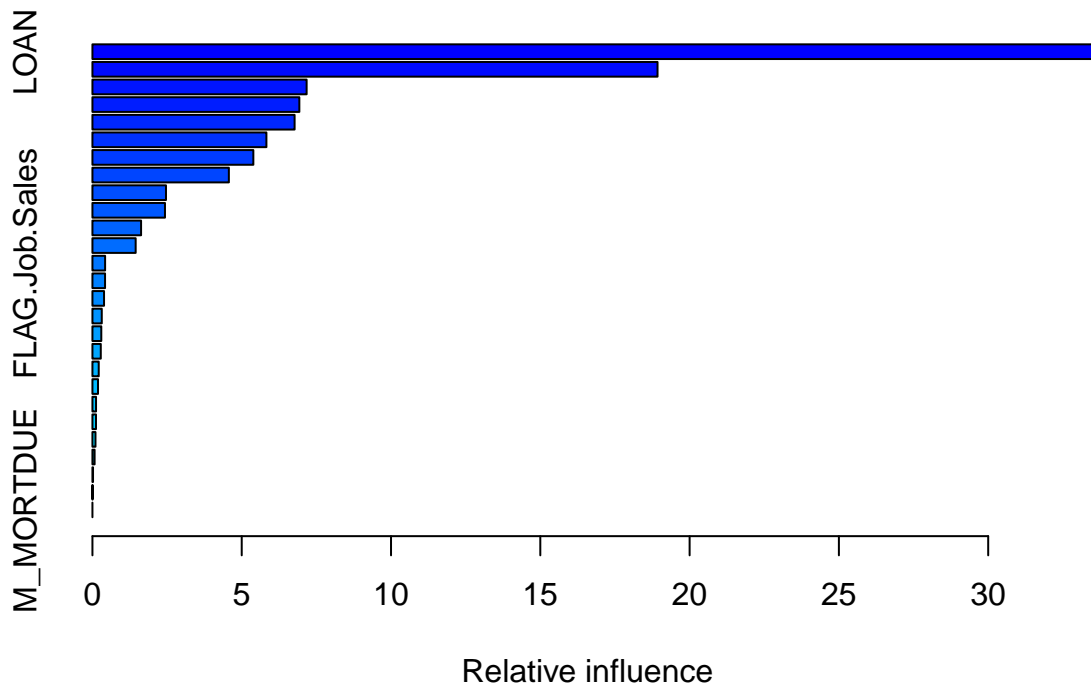


```
gb_model_s3 <- gbm(TARGET_LOSS_AMT ~ ., data = data_train_s3, n.trees = 1000, interaction.depth = 3)
```

GB

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

```
summary(gb_model_s3)
```



##	var	rel.inf
## LOAN	LOAN	33.488694845
## M_DEBTINC	M_DEBTINC	18.925626502
## IMP_CLAGE	IMP_CLAGE	7.173467735
## IMP_DELTINQ	IMP_DELTINQ	6.929981861
## IMP_DEBTINC	IMP_DEBTINC	6.770613691
## IMP_VALUE	IMP_VALUE	5.826304739
## IMP_CLNO	IMP_CLNO	5.388555759
## IMP_MORTDUE	IMP_MORTDUE	4.569205155
## IMP_DEROG	IMP_DEROG	2.463517864
## IMP_NINQ	IMP_NINQ	2.429260779
## IMP_YOJ	IMP_YOJ	1.628961430
## M_VALUE	M_VALUE	1.447996083
## FLAG.Job.Sales	FLAG.Job.Sales	0.424166321
## FLAG.Reason.DebtCon	FLAG.Reason.DebtCon	0.422174792
## FLAG.Job.Other	FLAG.Job.Other	0.388155263
## M_DEROG	M_DEROG	0.312746486
## FLAG.Reason.HomeImp	FLAG.Reason.HomeImp	0.296351372
## FLAG.Job.Mgr	FLAG.Job.Mgr	0.279732405
## M_DELTINQ	M_DELTINQ	0.211121379
## FLAG.Job.Self	FLAG.Job.Self	0.186570856
## FLAG.Job.Office	FLAG.Job.Office	0.120290578
## FLAG.Job.ProfExe	FLAG.Job.ProfExe	0.118463286
## M_CLNO	M_CLNO	0.101556339
## M_YOJ	M_YOJ	0.072442809
## M_NINQ	M_NINQ	0.019868077

```

## M_CLAGE                                M_CLAGE  0.004173594
## M_MORTDUE                              M_MORTDUE  0.000000000

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")

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

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

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

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

## [1] "RMSE Decision Tree: 8476.21683914098"

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

## [1] "RMSE Random Forest: 8154.46646036139"

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

##      [1] "RMSE Gradient Boosting: 1437.71571966257"
##      [2] "RMSE Gradient Boosting: 1972.28395262876"
##      [3] "RMSE Gradient Boosting: -2126.02585153955"
##      [4] "RMSE Gradient Boosting: 4151.3942159965"
##      [5] "RMSE Gradient Boosting: -2180.2383475384"
##      [6] "RMSE Gradient Boosting: 1530.80845648689"
##      [7] "RMSE Gradient Boosting: 944.573911396697"
##      [8] "RMSE Gradient Boosting: 3076.77088981243"
##      [9] "RMSE Gradient Boosting: -22.8232704133389"
##     [10] "RMSE Gradient Boosting: 1608.59110877337"
##     [11] "RMSE Gradient Boosting: 396.463669516293"
##     [12] "RMSE Gradient Boosting: 1423.28603693772"
##     [13] "RMSE Gradient Boosting: -168.238043286804"
##     [14] "RMSE Gradient Boosting: 7153.10160431847"
##     [15] "RMSE Gradient Boosting: 654.932464071244"
##     [16] "RMSE Gradient Boosting: 2160.37940379209"
##     [17] "RMSE Gradient Boosting: 2049.34792227553"

```

```

## [18] "RMSE Gradient Boosting: -521.911637116812"
## [19] "RMSE Gradient Boosting: 1941.63441091843"
## [20] "RMSE Gradient Boosting: 2526.07869235923"
## [21] "RMSE Gradient Boosting: 2050.14510846235"
## [22] "RMSE Gradient Boosting: 74.0768070458834"
## [23] "RMSE Gradient Boosting: -505.573759581534"
## [24] "RMSE Gradient Boosting: -939.703050544698"
## [25] "RMSE Gradient Boosting: 12528.0499633031"
## [26] "RMSE Gradient Boosting: 2530.29584395585"
## [27] "RMSE Gradient Boosting: 774.599066382499"
## [28] "RMSE Gradient Boosting: 6526.51518200842"
## [29] "RMSE Gradient Boosting: -1946.57184582306"
## [30] "RMSE Gradient Boosting: 3962.06733491831"
## [31] "RMSE Gradient Boosting: 2891.46178520806"
## [32] "RMSE Gradient Boosting: 2533.34425500975"
## [33] "RMSE Gradient Boosting: 84.3903827972921"
## [34] "RMSE Gradient Boosting: 999.244441134207"
## [35] "RMSE Gradient Boosting: 4685.10887413755"
## [36] "RMSE Gradient Boosting: 3395.27976678264"
## [37] "RMSE Gradient Boosting: -60.7958510152482"
## [38] "RMSE Gradient Boosting: 1691.82063092092"
## [39] "RMSE Gradient Boosting: 1314.31966067015"
## [40] "RMSE Gradient Boosting: -2146.73481587885"
## [41] "RMSE Gradient Boosting: 3064.57681599089"
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data_train_s3=data_amt[FLAG, ]
data_test_s3=data_amt[! FLAG, ]
```

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

```
2
```

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

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

```
## [1] 2669.894
```

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

```
## [1] 2685.353
```

```
dim(data_amt)
```

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

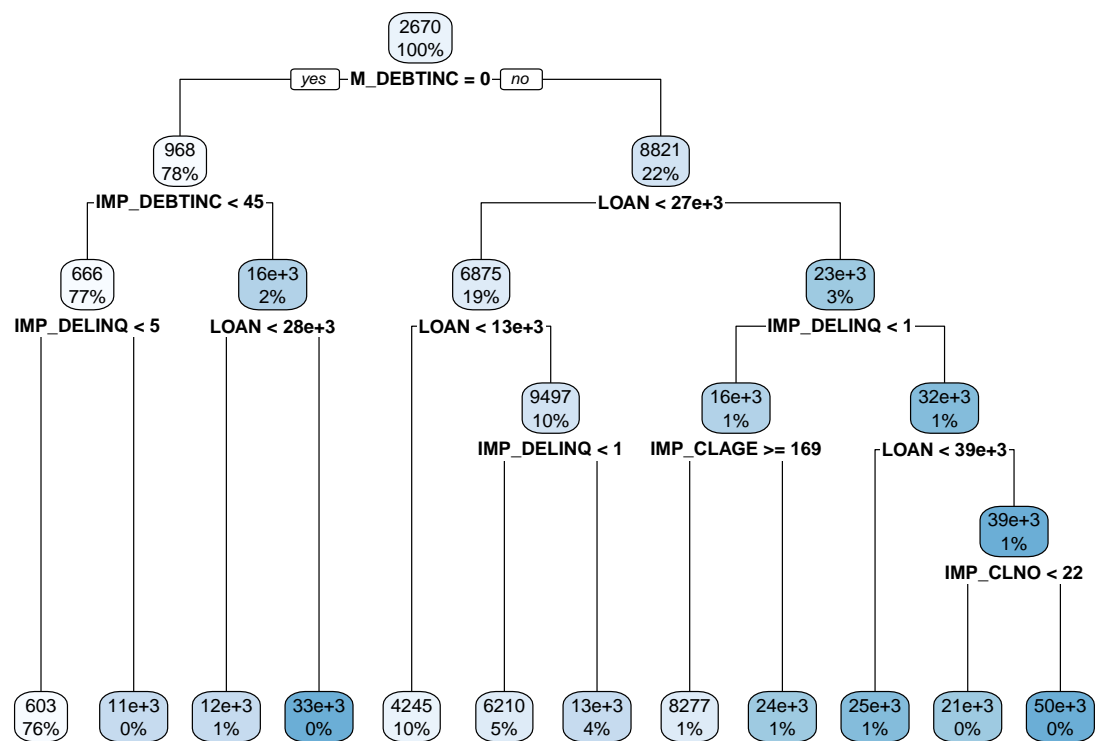
```
dim(data_train_s3)
```

```
## [1] 3543 28
```

```
dim(data_test_s3)
```

```
## [1] 2417 28
```

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



## Decision Tree

```
T1A$variable.importance
```

```
##          M_DEBTINC          LOAN          IMP_DELTINC          IMP_DELTINC
##      37094497026      36283706615      13936260590      12238599140
##          IMP_CLNO          IMP_VALUE          IMP_MORTDUE          IMP_DEROG
##      8441722232      7218689894      6409986262      3523570378
##          IMP_CLAGE          M_VALUE          IMP_NINQ          FLAG.Reason.HomeImp
##      3419561284      2635281306      2552353289      1491598309
## FLAG.Reason.DebtCon          IMP_YOJ          M_DEROG          M_DELTINC
##      1463976118      1404434633      1114504067      857310821
##          M_NINQ          FLAG.Job.Mgr
##      771579739      494664575
```

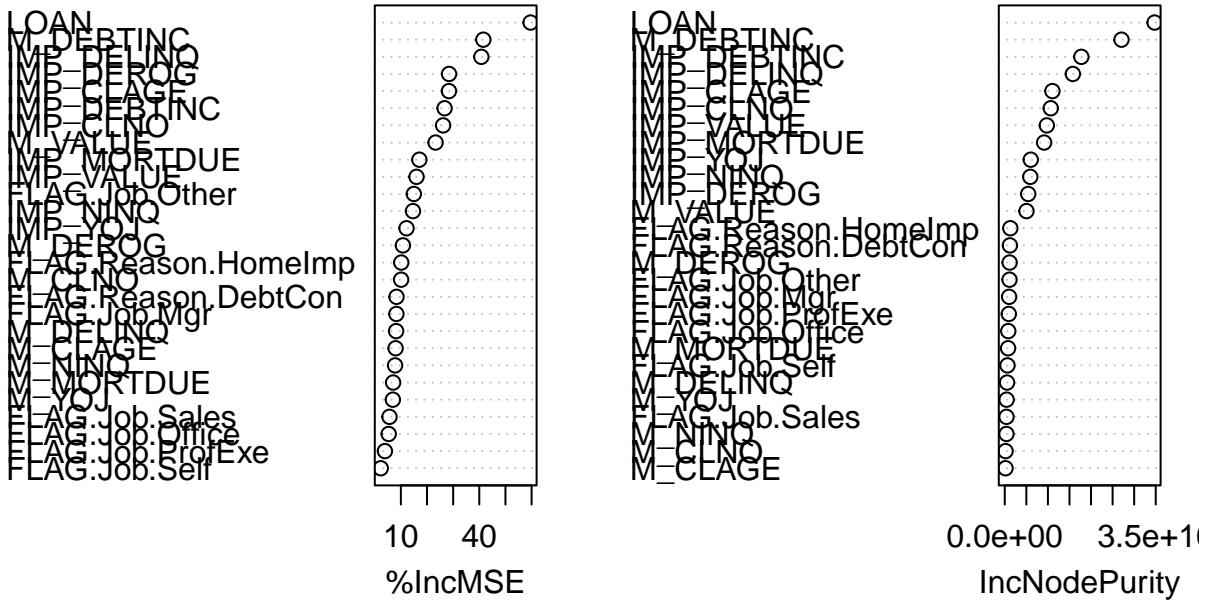
```
rf_model_s3 = randomForest(data = data_train_s3, TARGET_LOSS_AMT ~., ntree=500, importance= TRUE)
importance(rf_model_s3)
```

## RF

##	%IncMSE	IncNodePurity
## LOAN	59.623967	34738888333
## IMP_MORTDUE	17.080014	9129485112
## M_MORTDUE	7.044190	770686236
## IMP_VALUE	15.981574	9744865377
## M_VALUE	23.273102	5036973556
## IMP_YOJ	12.162742	6023703367
## M_YOJ	6.939985	427053136
## IMP_DEROG	28.442947	5430198715
## M_DEROG	10.779460	1131865888
## IMP_DELINQ	40.783765	15782269734
## M_DELINQ	8.177048	537262113
## IMP_CLAGE	28.390134	11042924897
## M_CLAGE	7.989817	175699652
## IMP_NINQ	14.626832	5911546179
## M_NINQ	7.787507	392603703
## IMP_CLNO	26.154609	10663597267
## M_CLNO	10.108712	188010013
## IMP_DEBTINC	26.721764	17751575869
## M_DEBTINC	41.535290	27067580365
## FLAG.Job.Mgr	8.293105	1011822667
## FLAG.Job.Office	5.332725	814054799
## FLAG.Job.Other	14.954977	1102229456
## FLAG.Job.ProfExe	3.899242	939364461
## FLAG.Job.Sales	5.640157	397467596
## FLAG.Job.Self	2.309871	628462779
## FLAG.Reason.DebtCon	8.333208	1192997006
## FLAG.Reason.HomeImp	10.165456	1286866465

```
varImpPlot(rf_model_s3)
```

rf\_model\_s3

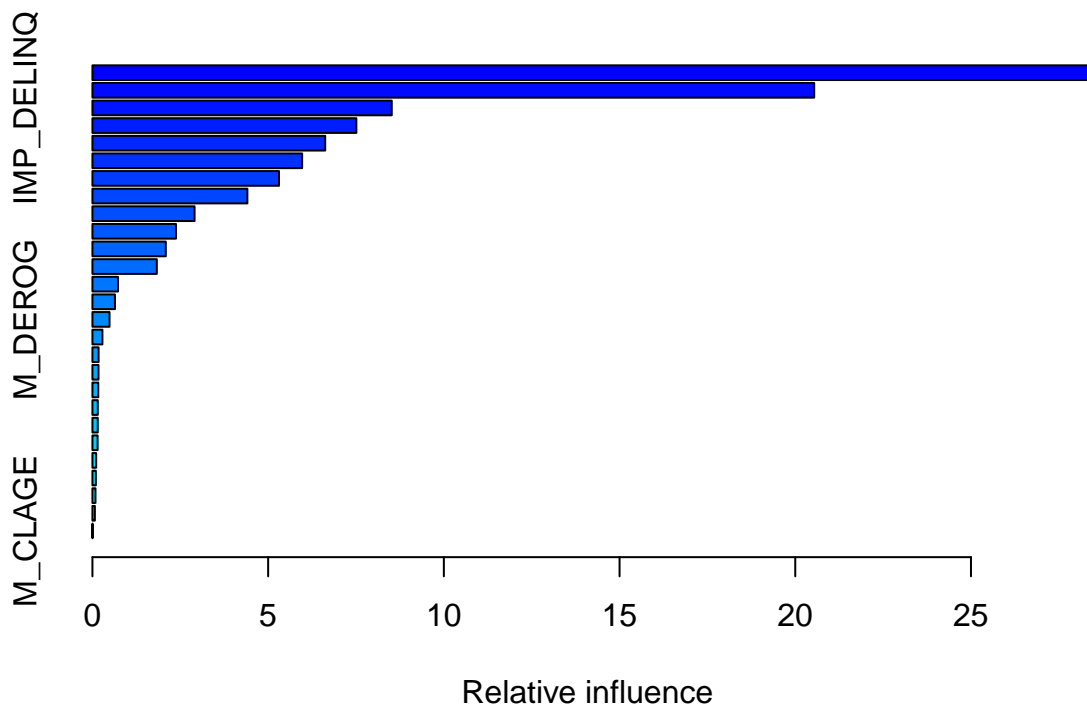


```
gb_model_s3 <- gbm(TARGET_LOSS_AMT ~ ., data = data_train_s3, n.trees = 1000, interaction.depth = 3)
```

GB

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

```
summary(gb_model_s3)
```



##	var	rel.inf
## LOAN	LOAN	28.454268950
## M_DEBTINC	M_DEBTINC	20.538487900
## IMP_DELINQ	IMP_DELINQ	8.517345340
## IMP_DEBTINC	IMP_DEBTINC	7.510538313
## IMP_CLAGE	IMP_CLAGE	6.623842982
## IMP_CLNO	IMP_CLNO	5.967427861
## IMP_MORTDUE	IMP_MORTDUE	5.308938397
## IMP_VALUE	IMP_VALUE	4.409026520
## IMP_NINQ	IMP_NINQ	2.906574908
## IMP_DEROG	IMP_DEROG	2.377398062
## M_VALUE	M_VALUE	2.087803818
## IMP_YOJ	IMP_YOJ	1.832141737
## FLAG.Job.Other	FLAG.Job.Other	0.727882202
## FLAG.Reason.DebtCon	FLAG.Reason.DebtCon	0.640576183
## M_DEROG	M_DEROG	0.486596645
## FLAG.Job.Mgr	FLAG.Job.Mgr	0.284017107
## M_DELINQ	M_DELINQ	0.175255531
## FLAG.Reason.HomeImp	FLAG.Reason.HomeImp	0.172559445
## M_CLNO	M_CLNO	0.166149211
## M_MORTDUE	M_MORTDUE	0.152699025
## FLAG.Job.Sales	FLAG.Job.Sales	0.151688232
## FLAG.Job.ProfExe	FLAG.Job.ProfExe	0.147582039
## M_YOJ	M_YOJ	0.105958294
## M_NINQ	M_NINQ	0.097417629
## FLAG.Job.Office	FLAG.Job.Office	0.086451265

```

## FLAG.Job.Self          FLAG.Job.Self  0.068690819
## M_CLAGE                M_CLAGE      0.002681585

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")

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

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

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

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

## [1] "RMSE Decision Tree: 8462.34983543803"

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

## [1] "RMSE Random Forest: 8153.88021922164"

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

## [1] "RMSE Gradient Boosting: 2416.63203593556"
## [2] "RMSE Gradient Boosting: 2305.7238403802"
## [3] "RMSE Gradient Boosting: -1071.02182215046"
## [4] "RMSE Gradient Boosting: 4597.68535246071"
## [5] "RMSE Gradient Boosting: 2722.4338956572"
## [6] "RMSE Gradient Boosting: -1019.87271722317"
## [7] "RMSE Gradient Boosting: 4111.73177292958"
## [8] "RMSE Gradient Boosting: 2243.26118487204"
## [9] "RMSE Gradient Boosting: 1541.08238287515"
## [10] "RMSE Gradient Boosting: 3578.57719636865"
## [11] "RMSE Gradient Boosting: 6725.15123575823"
## [12] "RMSE Gradient Boosting: 2479.62018164506"
## [13] "RMSE Gradient Boosting: 2258.15527015534"
## [14] "RMSE Gradient Boosting: 3150.86579755698"
## [15] "RMSE Gradient Boosting: -1420.81489812031"
## [16] "RMSE Gradient Boosting: 846.375081450789"
## [17] "RMSE Gradient Boosting: -481.794628428525"

```

```

## [18] "RMSE Gradient Boosting: 4260.33388045106"
## [19] "RMSE Gradient Boosting: 2124.9250879224"
## [20] "RMSE Gradient Boosting: 1196.80021282306"
## [21] "RMSE Gradient Boosting: -1816.36583962471"
## [22] "RMSE Gradient Boosting: -176.127464192413"
## [23] "RMSE Gradient Boosting: 6777.69989143667"
## [24] "RMSE Gradient Boosting: -1172.08016093473"
## [25] "RMSE Gradient Boosting: 2743.14355434382"
## [26] "RMSE Gradient Boosting: 1263.82969078937"
## [27] "RMSE Gradient Boosting: 1698.10311783414"
## [28] "RMSE Gradient Boosting: 5099.58262136197"
## [29] "RMSE Gradient Boosting: 1937.83066789126"
## [30] "RMSE Gradient Boosting: 753.957498924981"
## [31] "RMSE Gradient Boosting: 1706.89872659645"
## [32] "RMSE Gradient Boosting: 2176.02679952952"
## [33] "RMSE Gradient Boosting: -762.173631904944"
## [34] "RMSE Gradient Boosting: -1954.96666286162"
## [35] "RMSE Gradient Boosting: 2414.62096203023"
## [36] "RMSE Gradient Boosting: 7233.35225210935"
## [37] "RMSE Gradient Boosting: 3113.31395937169"
## [38] "RMSE Gradient Boosting: 1286.24020898192"
## [39] "RMSE Gradient Boosting: -654.661367253101"
## [40] "RMSE Gradient Boosting: -1038.63267961005"
## [41] "RMSE Gradient Boosting: 5356.79193042679"
## [42] "RMSE Gradient Boosting: -578.075033394514"
## [43] "RMSE Gradient Boosting: 5394.72555546656"
## [44] "RMSE Gradient Boosting: -1477.47060931341"
## [45] "RMSE Gradient Boosting: 1770.35423526723"
## [46] "RMSE Gradient Boosting: 3741.07230498325"
## [47] "RMSE Gradient Boosting: 4281.59741326002"
## [48] "RMSE Gradient Boosting: -874.446415516646"
## [49] "RMSE Gradient Boosting: -1498.54522988721"
## [50] "RMSE Gradient Boosting: -207.765342708403"
## [51] "RMSE Gradient Boosting: 3702.57514644688"
## [52] "RMSE Gradient Boosting: 2035.5406076816"
## [53] "RMSE Gradient Boosting: 3518.68863568467"
## [54] "RMSE Gradient Boosting: 2008.26169674018"
## [55] "RMSE Gradient Boosting: 4569.21773630168"
## [56] "RMSE Gradient Boosting: 2234.08738622935"
## [57] "RMSE Gradient Boosting: 3932.00650516721"
## [58] "RMSE Gradient Boosting: -978.972398977404"
## [59] "RMSE Gradient Boosting: -1008.45312572371"
## [60] "RMSE Gradient Boosting: -554.881799915561"
## [61] "RMSE Gradient Boosting: 4451.26462181111"
## [62] "RMSE Gradient Boosting: -1513.8801808533"
## [63] "RMSE Gradient Boosting: 3383.01506742654"
## [64] "RMSE Gradient Boosting: 3638.54953116701"
## [65] "RMSE Gradient Boosting: 2221.96955803595"
## [66] "RMSE Gradient Boosting: -224.278043230806"
## [67] "RMSE Gradient Boosting: -1324.960457937"
## [68] "RMSE Gradient Boosting: -145.930516109025"
## [69] "RMSE Gradient Boosting: -368.036216434392"
## [70] "RMSE Gradient Boosting: 1332.60253510354"
## [71] "RMSE Gradient Boosting: 1920.06032922697"

```



```

## [72] "RMSE Gradient Boosting: 158.440514357517"
## [73] "RMSE Gradient Boosting: 29.9976569432676"
## [74] "RMSE Gradient Boosting: -797.659359642072"
## [75] "RMSE Gradient Boosting: 3456.37628817766"
## [76] "RMSE Gradient Boosting: 5667.74150065186"
## [77] "RMSE Gradient Boosting: 2776.02201723659"
## [78] "RMSE Gradient Boosting: 5657.86778816636"
## [79] "RMSE Gradient Boosting: -413.556390084649"
## [80] "RMSE Gradient Boosting: -386.357130723527"
## [81] "RMSE Gradient Boosting: 3705.0637016001"
## [82] "RMSE Gradient Boosting: 5061.94995373466"
## [83] "RMSE Gradient Boosting: -359.054338554462"
## [84] "RMSE Gradient Boosting: 1303.84585206652"
## [85] "RMSE Gradient Boosting: -979.591315848639"
## [86] "RMSE Gradient Boosting: 122.359498641828"
## [87] "RMSE Gradient Boosting: -179.856629840866"
## [88] "RMSE Gradient Boosting: 2169.12563707126"
## [89] "RMSE Gradient Boosting: 2867.14622694989"
## [90] "RMSE Gradient Boosting: 795.681827866215"
## [91] "RMSE Gradient Boosting: -631.328098720444"
## [92] "RMSE Gradient Boosting: -574.364605169975"
## [93] "RMSE Gradient Boosting: -341.364698607279"
## [94] "RMSE Gradient Boosting: -1751.55459554882"
## [95] "RMSE Gradient Boosting: -1105.16051401707"
## [96] "RMSE Gradient Boosting: 2280.57674843322"
## [97] "RMSE Gradient Boosting: 3741.45633866157"
## [98] "RMSE Gradient Boosting: 3310.3406426213"
## [99] "RMSE Gradient Boosting: 2166.95689798492"
## [100] "RMSE Gradient Boosting: 3006.88243244617"
## [101] "RMSE Gradient Boosting: 3086.8123788441"
## [102] "RMSE Gradient Boosting: 2743.82920183514"
## [103] "RMSE Gradient Boosting: 1938.99894413771"
## [104] "RMSE Gradient Boosting: 3124.43943062337"
## [105] "RMSE Gradient Boosting: 2148.32149214536"
## [106] "RMSE Gradient Boosting: 2956.97300872898"
## [107] "RMSE Gradient Boosting: 5372.31398211256"
## [108] "RMSE Gradient Boosting: 4844.81804219272"
## [109] "RMSE Gradient Boosting: 1473.39698605232"
## [110] "RMSE Gradient Boosting: 7131.74393481953"
## [111] "RMSE Gradient Boosting: 2838.79706842391"
## [112] "RMSE Gradient Boosting: 4193.61623457047"
## [113] "RMSE Gradient Boosting: 4553.25264878851"
## [114] "RMSE Gradient Boosting: 2927.11468085745"
## [115] "RMSE Gradient Boosting: 6880.59265769005"
## [116] "RMSE Gradient Boosting: -1343.50813526937"
## [117] "RMSE Gradient Boosting: 3634.80487896496"
## [118] "RMSE Gradient Boosting: -569.055846018549"
## [119] "RMSE Gradient Boosting: 5348.13288868408"
## [120] "RMSE Gradient Boosting: -274.648766521033"
## [121] "RMSE Gradient Boosting: -411.650437003626"
## [122] "RMSE Gradient Boosting: -246.464667412725"
## [123] "RMSE Gradient Boosting: 3841.20632831261"
## [124] "RMSE Gradient Boosting: -568.839319935088"
## [125] "RMSE Gradient Boosting: -653.52670761402"

```

```

## [126] "RMSE Gradient Boosting: 2837.54905949333"
## [127] "RMSE Gradient Boosting: 3291.983964906"
## [128] "RMSE Gradient Boosting: -323.753386070331"
## [129] "RMSE Gradient Boosting: 799.718731959822"
## [130] "RMSE Gradient Boosting: -1146.3785647838"
## [131] "RMSE Gradient Boosting: 4534.78615642163"
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## [133] "RMSE Gradient Boosting: 56.6137610482356"
## [134] "RMSE Gradient Boosting: 1263.64834153977"
## [135] "RMSE Gradient Boosting: -269.929516781042"
## [136] "RMSE Gradient Boosting: -600.529789156499"
## [137] "RMSE Gradient Boosting: -1101.12353594433"
## [138] "RMSE Gradient Boosting: 3402.80827659856"
## [139] "RMSE Gradient Boosting: -631.707450005296"
## [140] "RMSE Gradient Boosting: -419.438781582996"
## [141] "RMSE Gradient Boosting: -645.869153420574"
## [142] "RMSE Gradient Boosting: -1045.36590100325"
## [143] "RMSE Gradient Boosting: 546.383229563594"
## [144] "RMSE Gradient Boosting: 4374.56806815551"
## [145] "RMSE Gradient Boosting: 2807.53129252937"
## [146] "RMSE Gradient Boosting: 334.173416682002"
## [147] "RMSE Gradient Boosting: -550.145054685124"
## [148] "RMSE Gradient Boosting: -434.198528234871"
## [149] "RMSE Gradient Boosting: 1024.41898681909"
## [150] "RMSE Gradient Boosting: -342.423885226899"
## [151] "RMSE Gradient Boosting: 7213.19942720547"
## [152] "RMSE Gradient Boosting: 3872.41716050083"
## [153] "RMSE Gradient Boosting: 5617.74654772478"
## [154] "RMSE Gradient Boosting: 2538.7936717332"
## [155] "RMSE Gradient Boosting: -451.156578526366"
## [156] "RMSE Gradient Boosting: -827.258744937115"
## [157] "RMSE Gradient Boosting: 166.882608351448"
## [158] "RMSE Gradient Boosting: 1139.36959083325"
## [159] "RMSE Gradient Boosting: 566.504202889827"
## [160] "RMSE Gradient Boosting: 2169.75320645922"
## [161] "RMSE Gradient Boosting: 816.173724425098"
## [162] "RMSE Gradient Boosting: -503.745919422298"
## [163] "RMSE Gradient Boosting: 204.216483756099"
## [164] "RMSE Gradient Boosting: -99.0361137275393"
## [165] "RMSE Gradient Boosting: 3416.14963415464"
## [166] "RMSE Gradient Boosting: -1045.94123920405"
## [167] "RMSE Gradient Boosting: -252.234226277578"
## [168] "RMSE Gradient Boosting: -367.337466893654"
## [169] "RMSE Gradient Boosting: -434.198528234871"
## [170] "RMSE Gradient Boosting: -181.916436832973"
## [171] "RMSE Gradient Boosting: -380.733097473424"
## [172] "RMSE Gradient Boosting: 873.919202494036"
## [173] "RMSE Gradient Boosting: 5579.69259405741"
## [174] "RMSE Gradient Boosting: 2533.43813114307"
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## [176] "RMSE Gradient Boosting: 366.850534313672"
## [177] "RMSE Gradient Boosting: 8656.64662606558"
## [178] "RMSE Gradient Boosting: 873.919202494036"
## [179] "RMSE Gradient Boosting: 184.842056904945"

```

```

## [180] "RMSE Gradient Boosting: 423.268909201617"
## [181] "RMSE Gradient Boosting: 114.656156099881"
## [182] "RMSE Gradient Boosting: 713.098901659182"
## [183] "RMSE Gradient Boosting: 414.153917202975"
## [184] "RMSE Gradient Boosting: 425.647118540527"
## [185] "RMSE Gradient Boosting: 323.306047500873"
## [186] "RMSE Gradient Boosting: 1198.04372952744"
## [187] "RMSE Gradient Boosting: -606.55922067204"
## [188] "RMSE Gradient Boosting: -293.789396401594"
## [189] "RMSE Gradient Boosting: 3608.38348395963"
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## [192] "RMSE Gradient Boosting: -434.198528234871"
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## [195] "RMSE Gradient Boosting: 8308.58684670037"
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## [198] "RMSE Gradient Boosting: 6335.40848944713"
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## [200] "RMSE Gradient Boosting: 222.582196542353"
## [201] "RMSE Gradient Boosting: 2601.37065592295"
## [202] "RMSE Gradient Boosting: 3662.38131177798"
## [203] "RMSE Gradient Boosting: 2135.19073700905"
## [204] "RMSE Gradient Boosting: 4691.33528679479"
## [205] "RMSE Gradient Boosting: 2123.26477948673"
## [206] "RMSE Gradient Boosting: 12831.9177221338"
## [207] "RMSE Gradient Boosting: -779.600922694221"
## [208] "RMSE Gradient Boosting: 1383.88050338021"
## [209] "RMSE Gradient Boosting: 3082.50290787785"
## [210] "RMSE Gradient Boosting: 115.072096348423"
## [211] "RMSE Gradient Boosting: -1060.40285576016"
## [212] "RMSE Gradient Boosting: -198.580751918747"
## [213] "RMSE Gradient Boosting: 189.476590803038"
## [214] "RMSE Gradient Boosting: -645.869153420574"
## [215] "RMSE Gradient Boosting: 889.159438132304"
## [216] "RMSE Gradient Boosting: 222.460873171245"
## [217] "RMSE Gradient Boosting: 347.20474786456"
## [218] "RMSE Gradient Boosting: -614.623592618495"
## [219] "RMSE Gradient Boosting: 4746.56286135356"
## [220] "RMSE Gradient Boosting: -192.107881140406"
## [221] "RMSE Gradient Boosting: 611.413439669031"
## [222] "RMSE Gradient Boosting: -798.966077889924"
## [223] "RMSE Gradient Boosting: 4675.41598824626"
## [224] "RMSE Gradient Boosting: 1511.57542223311"
## [225] "RMSE Gradient Boosting: -472.827451398393"
## [226] "RMSE Gradient Boosting: 2628.41481713273"
## [227] "RMSE Gradient Boosting: 4880.099099797"
## [228] "RMSE Gradient Boosting: 235.339669860304"
## [229] "RMSE Gradient Boosting: 1551.75535537124"
## [230] "RMSE Gradient Boosting: -1172.97821678156"
## [231] "RMSE Gradient Boosting: -128.347528842677"
## [232] "RMSE Gradient Boosting: -26.6337078894155"
## [233] "RMSE Gradient Boosting: -524.797800747221"

```

```

## [234] "RMSE Gradient Boosting: 653.920688387397"
## [235] "RMSE Gradient Boosting: -166.156329800069"
## [236] "RMSE Gradient Boosting: -517.872724787961"
## [237] "RMSE Gradient Boosting: 7398.13256048133"
## [238] "RMSE Gradient Boosting: 8912.70026087537"
## [239] "RMSE Gradient Boosting: 1647.23741567027"
## [240] "RMSE Gradient Boosting: 4844.14889561784"
## [241] "RMSE Gradient Boosting: -1266.68168771273"
## [242] "RMSE Gradient Boosting: -480.136597780236"
## [243] "RMSE Gradient Boosting: -1022.63206770294"
## [244] "RMSE Gradient Boosting: -434.198528234871"
## [245] "RMSE Gradient Boosting: 834.15235894785"
## [246] "RMSE Gradient Boosting: -620.589405575177"
## [247] "RMSE Gradient Boosting: -541.106733910403"
## [248] "RMSE Gradient Boosting: 857.995755086999"
## [249] "RMSE Gradient Boosting: -390.163510575243"
## [250] "RMSE Gradient Boosting: -374.775472988774"
## [251] "RMSE Gradient Boosting: -412.278374486845"
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## [3343] "RMSE Gradient Boosting: 6756.5023704908"
## [3344] "RMSE Gradient Boosting: -809.593142436666"
## [3345] "RMSE Gradient Boosting: 1540.32034517363"
## [3346] "RMSE Gradient Boosting: 3364.27365364654"
## [3347] "RMSE Gradient Boosting: 5077.6851409795"
## [3348] "RMSE Gradient Boosting: -620.291879906045"
## [3349] "RMSE Gradient Boosting: 1221.86482547485"
## [3350] "RMSE Gradient Boosting: 1313.74412737717"
## [3351] "RMSE Gradient Boosting: -298.511522602176"
## [3352] "RMSE Gradient Boosting: 28204.3387992256"
## [3353] "RMSE Gradient Boosting: -643.996266760406"
## [3354] "RMSE Gradient Boosting: 12443.6394386461"
## [3355] "RMSE Gradient Boosting: 6896.45100228089"
## [3356] "RMSE Gradient Boosting: 1527.07621789973"
## [3357] "RMSE Gradient Boosting: 576.243868337043"
## [3358] "RMSE Gradient Boosting: 2370.4260353302"
## [3359] "RMSE Gradient Boosting: 25858.8727140515"
## [3360] "RMSE Gradient Boosting: 3155.72926431069"
## [3361] "RMSE Gradient Boosting: 794.831518679955"
## [3362] "RMSE Gradient Boosting: 1183.42020501965"
## [3363] "RMSE Gradient Boosting: 29374.3477981565"
## [3364] "RMSE Gradient Boosting: 1410.62000881289"
## [3365] "RMSE Gradient Boosting: 25810.9549077869"

```

```

## [3366] "RMSE Gradient Boosting: 2578.22538966175"
## [3367] "RMSE Gradient Boosting: 8939.73168547337"
## [3368] "RMSE Gradient Boosting: 50513.1668622363"
## [3369] "RMSE Gradient Boosting: 59218.0317678691"
## [3370] "RMSE Gradient Boosting: 30938.0892444998"
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## [3378] "RMSE Gradient Boosting: 2029.13977315862"
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## [3383] "RMSE Gradient Boosting: -110.585944070638"
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## [3385] "RMSE Gradient Boosting: 5404.22578107033"
## [3386] "RMSE Gradient Boosting: 17380.5583314901"
## [3387] "RMSE Gradient Boosting: 675.680193881134"
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## [3389] "RMSE Gradient Boosting: 3001.97380400611"
## [3390] "RMSE Gradient Boosting: -83.2026527398915"
## [3391] "RMSE Gradient Boosting: 51141.749948821"
## [3392] "RMSE Gradient Boosting: -974.744943232095"
## [3393] "RMSE Gradient Boosting: 3315.86489971791"
## [3394] "RMSE Gradient Boosting: -903.57343935501"
## [3395] "RMSE Gradient Boosting: 25428.8924692808"
## [3396] "RMSE Gradient Boosting: 19664.947171698"
## [3397] "RMSE Gradient Boosting: 23421.6992415244"
## [3398] "RMSE Gradient Boosting: 3444.11977012301"
## [3399] "RMSE Gradient Boosting: -1077.968569004"
## [3400] "RMSE Gradient Boosting: -1455.40640509024"
## [3401] "RMSE Gradient Boosting: 11224.7031441549"
## [3402] "RMSE Gradient Boosting: 11144.4740226651"
## [3403] "RMSE Gradient Boosting: 2506.10206419097"
## [3404] "RMSE Gradient Boosting: -502.935689126133"
## [3405] "RMSE Gradient Boosting: -992.086830782658"
## [3406] "RMSE Gradient Boosting: -717.386041143191"
## [3407] "RMSE Gradient Boosting: -463.047394759121"
## [3408] "RMSE Gradient Boosting: 1149.567078471"
## [3409] "RMSE Gradient Boosting: -628.473546806654"
## [3410] "RMSE Gradient Boosting: -614.895296743422"
## [3411] "RMSE Gradient Boosting: 2972.84495405264"
## [3412] "RMSE Gradient Boosting: -2066.35336723376"
## [3413] "RMSE Gradient Boosting: 2358.38800155299"
## [3414] "RMSE Gradient Boosting: 4807.48725897901"
## [3415] "RMSE Gradient Boosting: 3338.55606931315"
## [3416] "RMSE Gradient Boosting: -233.479328677441"
## [3417] "RMSE Gradient Boosting: 3814.33715542928"
## [3418] "RMSE Gradient Boosting: 3070.99504592345"
## [3419] "RMSE Gradient Boosting: 7630.12419133933"

```

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## [3420] "RMSE Gradient Boosting: 2457.17345702541"
## [3421] "RMSE Gradient Boosting: -2076.06251749485"
## [3422] "RMSE Gradient Boosting: 3203.03682977608"
## [3423] "RMSE Gradient Boosting: 2442.57145848005"
## [3424] "RMSE Gradient Boosting: 2129.47877275731"
## [3425] "RMSE Gradient Boosting: 4773.71130450759"
## [3426] "RMSE Gradient Boosting: 2276.37058143947"
## [3427] "RMSE Gradient Boosting: 4677.27096021123"
## [3428] "RMSE Gradient Boosting: 11694.9761894728"
## [3429] "RMSE Gradient Boosting: 5859.62435823596"
## [3430] "RMSE Gradient Boosting: 31433.2997493022"
## [3431] "RMSE Gradient Boosting: 21614.222987602"
## [3432] "RMSE Gradient Boosting: -581.543433278381"
## [3433] "RMSE Gradient Boosting: 26975.9961756462"
## [3434] "RMSE Gradient Boosting: 11482.0138258084"
## [3435] "RMSE Gradient Boosting: 49477.3528937441"
## [3436] "RMSE Gradient Boosting: -1203.74239485768"
## [3437] "RMSE Gradient Boosting: 1855.61711499379"
## [3438] "RMSE Gradient Boosting: 709.018176730146"
## [3439] "RMSE Gradient Boosting: -1586.24298121846"
## [3440] "RMSE Gradient Boosting: -468.850243456563"
## [3441] "RMSE Gradient Boosting: 1296.87936141859"
## [3442] "RMSE Gradient Boosting: 9816.22104721157"
## [3443] "RMSE Gradient Boosting: 3168.45223372928"
## [3444] "RMSE Gradient Boosting: -1629.57745989016"
## [3445] "RMSE Gradient Boosting: 49206.5421376755"
## [3446] "RMSE Gradient Boosting: 10435.358139214"
## [3447] "RMSE Gradient Boosting: -211.647987384657"
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## [3449] "RMSE Gradient Boosting: 48548.8160504739"
## [3450] "RMSE Gradient Boosting: 48936.2078305909"
## [3451] "RMSE Gradient Boosting: 6864.21313863283"
## [3452] "RMSE Gradient Boosting: 17336.8702626984"
## [3453] "RMSE Gradient Boosting: 54634.2161926758"
## [3454] "RMSE Gradient Boosting: 28592.0291843971"
## [3455] "RMSE Gradient Boosting: 43997.79926627"
## [3456] "RMSE Gradient Boosting: 48138.3089590826"
## [3457] "RMSE Gradient Boosting: 49620.5914041605"
## [3458] "RMSE Gradient Boosting: 1117.81359623584"
## [3459] "RMSE Gradient Boosting: 24325.4507724186"
## [3460] "RMSE Gradient Boosting: 724.667850346511"
## [3461] "RMSE Gradient Boosting: 21566.7415544231"
## [3462] "RMSE Gradient Boosting: 4985.01876189953"
## [3463] "RMSE Gradient Boosting: 47700.1727629686"
## [3464] "RMSE Gradient Boosting: 1370.14264860322"
## [3465] "RMSE Gradient Boosting: 16851.5015384505"
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## [3467] "RMSE Gradient Boosting: -1343.66691617014"
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## [3469] "RMSE Gradient Boosting: 1874.34002559723"
## [3470] "RMSE Gradient Boosting: -1354.92327889262"
## [3471] "RMSE Gradient Boosting: -540.07754012119"
## [3472] "RMSE Gradient Boosting: 2861.31031978767"
## [3473] "RMSE Gradient Boosting: 352.828619107403"

```

```

## [3474] "RMSE Gradient Boosting: -839.45355205548"
## [3475] "RMSE Gradient Boosting: 3148.3775727259"
## [3476] "RMSE Gradient Boosting: -2460.26926094347"
## [3477] "RMSE Gradient Boosting: -980.764079819164"
## [3478] "RMSE Gradient Boosting: -3164.91725506668"
## [3479] "RMSE Gradient Boosting: -1434.08037635301"
## [3480] "RMSE Gradient Boosting: 1592.49343493397"
## [3481] "RMSE Gradient Boosting: -442.458400979393"
## [3482] "RMSE Gradient Boosting: -486.797153360692"
## [3483] "RMSE Gradient Boosting: -466.321952834526"
## [3484] "RMSE Gradient Boosting: -424.137486690257"
## [3485] "RMSE Gradient Boosting: 932.722752470874"
## [3486] "RMSE Gradient Boosting: 944.93042645926"
## [3487] "RMSE Gradient Boosting: 778.403587267542"
## [3488] "RMSE Gradient Boosting: -140.475734636695"
## [3489] "RMSE Gradient Boosting: 1845.95447928453"
## [3490] "RMSE Gradient Boosting: -1406.20310262208"
## [3491] "RMSE Gradient Boosting: 1303.56507079398"
## [3492] "RMSE Gradient Boosting: 32672.9177540301"
## [3493] "RMSE Gradient Boosting: 1607.99123499679"
## [3494] "RMSE Gradient Boosting: 2312.61355815801"
## [3495] "RMSE Gradient Boosting: -424.732372555669"
## [3496] "RMSE Gradient Boosting: 40629.5898512087"
## [3497] "RMSE Gradient Boosting: 5749.21615009388"
## [3498] "RMSE Gradient Boosting: 1883.39632182924"
## [3499] "RMSE Gradient Boosting: 47112.1988089001"
## [3500] "RMSE Gradient Boosting: 14140.6517377726"
## [3501] "RMSE Gradient Boosting: -1175.9916053652"
## [3502] "RMSE Gradient Boosting: -709.089590273377"
## [3503] "RMSE Gradient Boosting: 7008.7570292407"
## [3504] "RMSE Gradient Boosting: -917.9483869533"
## [3505] "RMSE Gradient Boosting: -142.104475713611"
## [3506] "RMSE Gradient Boosting: 48495.3862283164"
## [3507] "RMSE Gradient Boosting: -1298.57811478518"
## [3508] "RMSE Gradient Boosting: -1175.99743882726"
## [3509] "RMSE Gradient Boosting: 979.20957467798"
## [3510] "RMSE Gradient Boosting: -2554.88642549817"
## [3511] "RMSE Gradient Boosting: -2497.05536634037"
## [3512] "RMSE Gradient Boosting: -1857.67562650593"
## [3513] "RMSE Gradient Boosting: 8917.02837021587"
## [3514] "RMSE Gradient Boosting: -1852.06219702469"
## [3515] "RMSE Gradient Boosting: 768.426468480896"
## [3516] "RMSE Gradient Boosting: 1801.52356601387"
## [3517] "RMSE Gradient Boosting: -1862.20415801333"
## [3518] "RMSE Gradient Boosting: -2945.8278943248"
## [3519] "RMSE Gradient Boosting: 2443.70419435414"
## [3520] "RMSE Gradient Boosting: -1977.85010670226"
## [3521] "RMSE Gradient Boosting: 3057.36836963061"
## [3522] "RMSE Gradient Boosting: -1623.10336921343"
## [3523] "RMSE Gradient Boosting: -2491.0929226088"
## [3524] "RMSE Gradient Boosting: -108.11168815518"
## [3525] "RMSE Gradient Boosting: 655.55061734596"
## [3526] "RMSE Gradient Boosting: 2473.73509734139"
## [3527] "RMSE Gradient Boosting: 37591.778048651"

```



```
## [3528] "RMSE Gradient Boosting: 5866.35356259815"
## [3529] "RMSE Gradient Boosting: -238.248522609301"
## [3530] "RMSE Gradient Boosting: -238.248522609301"
## [3531] "RMSE Gradient Boosting: 176.425900886218"
## [3532] "RMSE Gradient Boosting: -2065.37881357105"
## [3533] "RMSE Gradient Boosting: -1879.37434675529"
## [3534] "RMSE Gradient Boosting: 4773.40381306385"
## [3535] "RMSE Gradient Boosting: -355.200672180789"
## [3536] "RMSE Gradient Boosting: 1929.43409317289"
## [3537] "RMSE Gradient Boosting: 194.586480817768"
## [3538] "RMSE Gradient Boosting: 601.980496957472"
## [3539] "RMSE Gradient Boosting: 257.719120562948"
## [3540] "RMSE Gradient Boosting: 1917.96320321786"
## [3541] "RMSE Gradient Boosting: -601.468660689241"
## [3542] "RMSE Gradient Boosting: 612.540748714469"
## [3543] "RMSE Gradient Boosting: 1143.88623359753"
```

```
FLAG=sample(c(TRUE,FALSE), nrow(data_amt), replace=TRUE, prob=c(0.8,0.2))
data_train_s3=data_amt[FLAG, ]
data_test_s3=data_amt[! FLAG, ]
```

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

3

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

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

```
## [1] 2675.23
```

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

```
## [1] 2679.922
```

```
dim(data_amt)
```

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

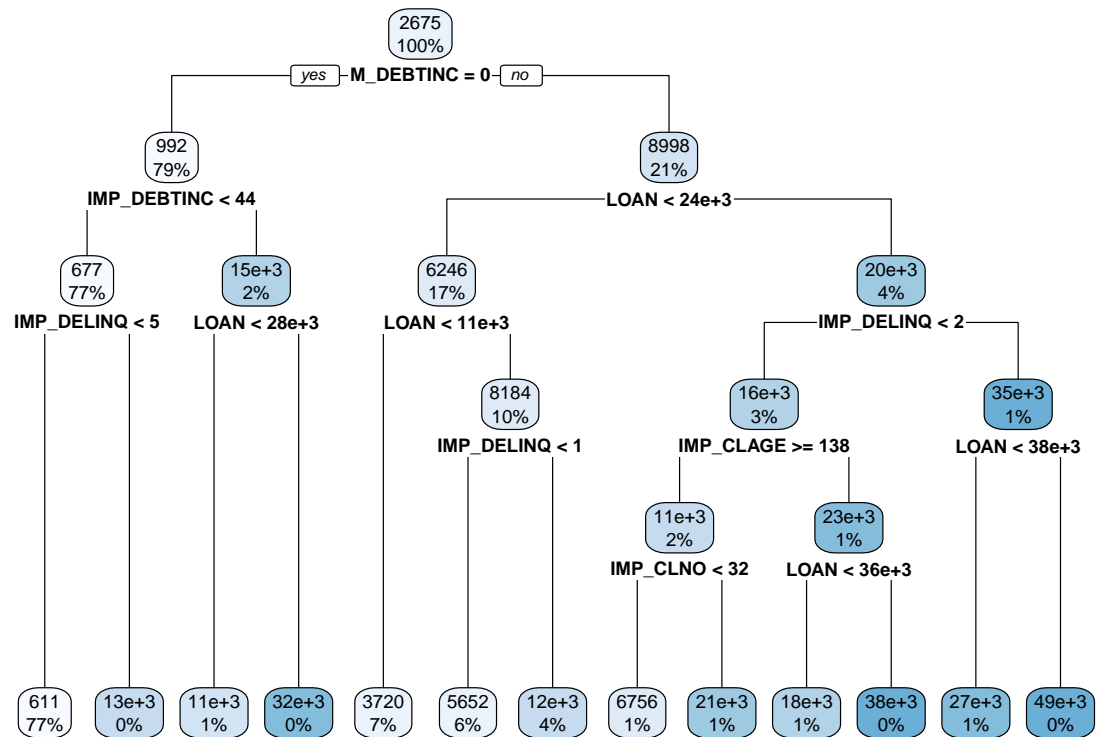
```
dim(data_train_s3)
```

```
## [1] 4775 28
```

```
dim(data_test_s3)
```

```
## [1] 1185 28
```

```
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_DELINQ	IMP_DEBTINC
##	52427001494	50817869541	21660159632	16230497904
##	IMP_VALUE	IMP_CLAGE	IMP_CLNO	IMP_MORTDUE
##	7062650898	6811532633	6095103946	5076155447
##	IMP_DEROG	M_VALUE	M_DEROG	FLAG.Reason.HomeImp
##	2918423623	2638646766	1251527202	1246110175
##	M_NINQ	M_DELINQ	IMP_YOJ	FLAG.Reason.DebtCon
##	1121193316	1030669461	930297754	834347354
##	M_CLNO	IMP_NINQ	FLAG.Job.Self	
##	638033476	594253272	310099251	

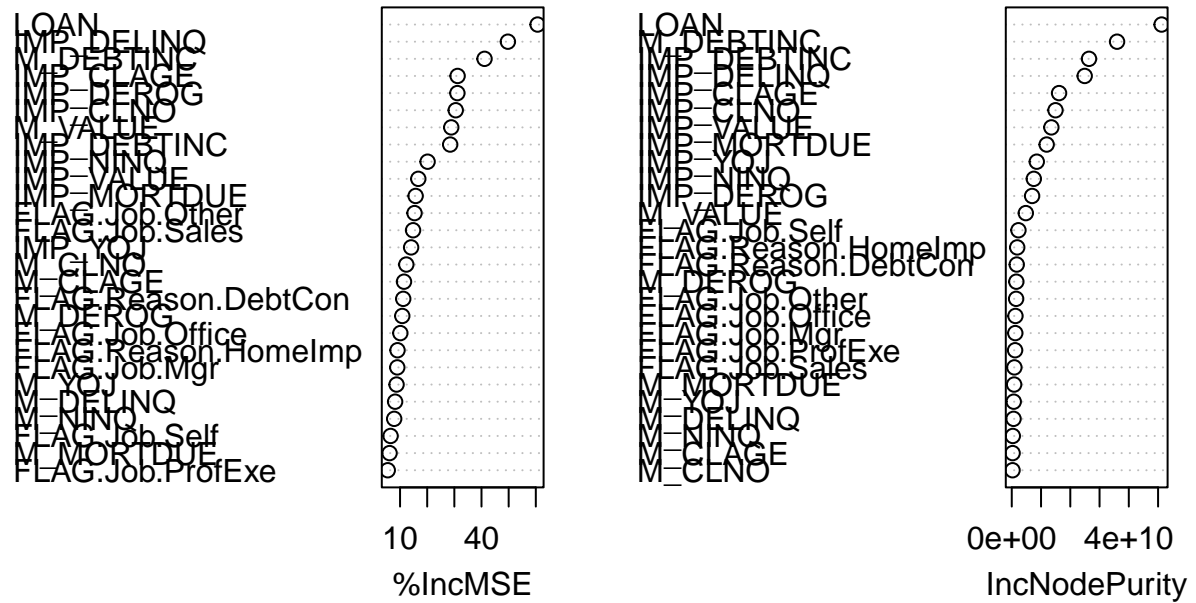
```
rf_model_s3 = randomForest(data = data_train_s3, TARGET_LOSS_AMT ~., ntree=500, importance= TRUE)
importance(rf_model_s3)
```

## RF

##	%IncMSE	IncNodePurity
## LOAN	60.663111	51208046427
## IMP_MORTDUE	15.737812	11929283202
## M_MORTDUE	6.140515	806576007
## IMP_VALUE	16.713771	13526721568
## M_VALUE	28.861826	4796828523
## IMP_YOJ	14.077512	8541984239
## M_YOJ	8.709906	672747633
## IMP_DEROG	31.113606	6953339301
## M_DEROG	10.814723	1562403998
## IMP_DELINQ	49.721578	24919370721
## M_DELINQ	8.185346	610847052
## IMP_CLAGE	31.198562	16168637303
## M_CLAGE	11.456414	284027646
## IMP_NINQ	20.144594	7531460948
## M_NINQ	7.839769	350943668
## IMP_CLNO	30.507025	14943468597
## M_CLNO	12.309948	265285806
## IMP_DEBTINC	28.465412	26399709969
## M_DEBTINC	41.120281	35988863501
## FLAG.Job.Mgr	8.977995	1195848867
## FLAG.Job.Office	10.107697	1255025498
## FLAG.Job.Other	15.331053	1493656773
## FLAG.Job.ProfExe	5.476175	1138464022
## FLAG.Job.Sales	14.796167	893638089
## FLAG.Job.Self	6.510107	2282448482
## FLAG.Reason.DebtCon	11.166850	1698108133
## FLAG.Reason.HomeImp	9.065078	1867747662

```
varImpPlot(rf_model_s3)
```

rf\_model\_s3

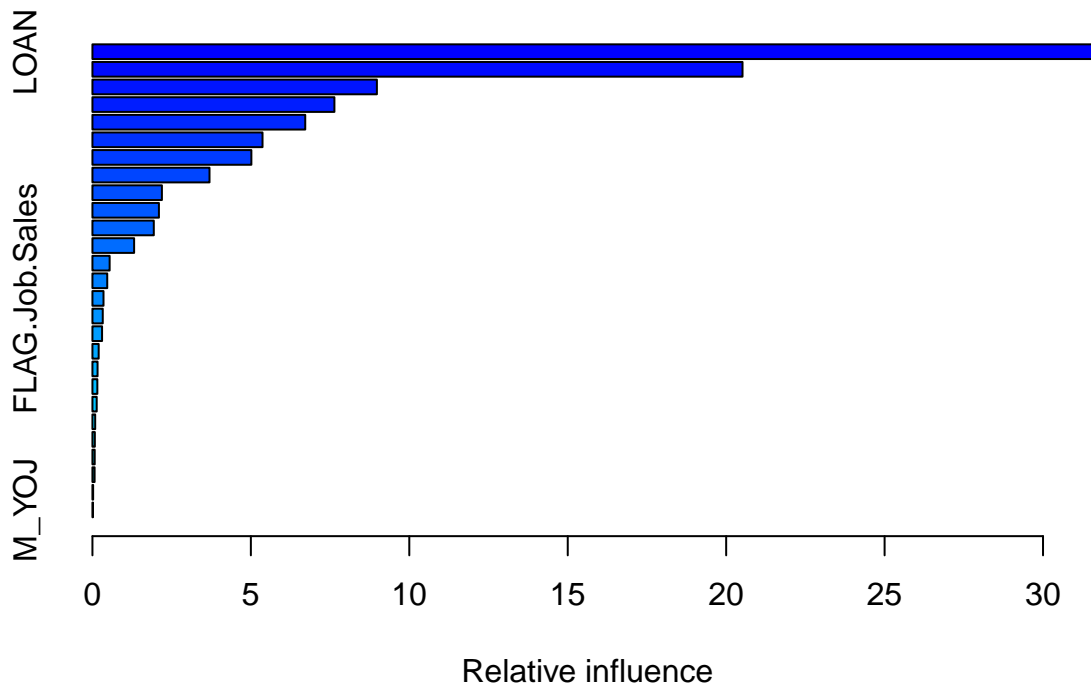


```
gb_model_s3 <- gbm(TARGET_LOSS_AMT ~ ., data = data_train_s3, n.trees = 1000, interaction.depth = 3)
```

GB

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

```
summary(gb_model_s3)
```



##	var	rel.inf
## LOAN	LOAN	31.55655419
## M_DEBTINC	M_DEBTINC	20.51603779
## IMP_DELTINC	IMP_DELTINC	8.97671632
## IMP_DEBTINC	IMP_DEBTINC	7.63686810
## IMP_CLAGE	IMP_CLAGE	6.71570177
## IMP_CLNO	IMP_CLNO	5.36774414
## IMP_VALUE	IMP_VALUE	5.01605141
## IMP_MORTDUE	IMP_MORTDUE	3.69449699
## IMP_DEROG	IMP_DEROG	2.19269420
## IMP_NINQ	IMP_NINQ	2.09786151
## IMP_YOJ	IMP_YOJ	1.93617739
## M_VALUE	M_VALUE	1.31574836
## FLAG.Job.Other	FLAG.Job.Other	0.54322723
## M_DEROG	M_DEROG	0.46691991
## FLAG.Job.Sales	FLAG.Job.Sales	0.34923663
## FLAG.Reason.DebtCon	FLAG.Reason.DebtCon	0.32572061
## FLAG.Job.Self	FLAG.Job.Self	0.30383983
## FLAG.Job.Mgr	FLAG.Job.Mgr	0.19673453
## M_CLNO	M_CLNO	0.16143573
## FLAG.Reason.HomeImp	FLAG.Reason.HomeImp	0.15450863
## FLAG.Job.Office	FLAG.Job.Office	0.13460849
## M_DELTINC	M_DELTINC	0.08628428
## M_CLAGE	M_CLAGE	0.07535908
## FLAG.Job.ProfExe	FLAG.Job.ProfExe	0.07177465
## M_MORTDUE	M_MORTDUE	0.06779067

```

## M_NINQ                                M_NINQ  0.02215805
## M_YOJ                                M_YOJ  0.01774947

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")

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

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

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

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

## [1] "RMSE Decision Tree: 9151.64426973394"

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

## [1] "RMSE Random Forest: 8833.71969756675"

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

## [1] "RMSE Gradient Boosting: 1418.98923531787"
## [2] "RMSE Gradient Boosting: 2786.15347574345"
## [3] "RMSE Gradient Boosting: 532.863333502323"
## [4] "RMSE Gradient Boosting: 1544.73723985646"
## [5] "RMSE Gradient Boosting: -939.017705226959"
## [6] "RMSE Gradient Boosting: 5272.45694399205"
## [7] "RMSE Gradient Boosting: -846.642534715938"
## [8] "RMSE Gradient Boosting: 1327.07636449367"
## [9] "RMSE Gradient Boosting: 1317.87015715981"
## [10] "RMSE Gradient Boosting: 2406.51978320651"
## [11] "RMSE Gradient Boosting: 2582.65178691775"
## [12] "RMSE Gradient Boosting: 2480.01151662268"
## [13] "RMSE Gradient Boosting: -1182.90935013386"
## [14] "RMSE Gradient Boosting: 3278.74414611052"
## [15] "RMSE Gradient Boosting: 490.152138142855"
## [16] "RMSE Gradient Boosting: 4637.08863302632"
## [17] "RMSE Gradient Boosting: -1023.4029851313"

```

```

## [18] "RMSE Gradient Boosting: 1213.60907288346"
## [19] "RMSE Gradient Boosting: 1368.17719483262"
## [20] "RMSE Gradient Boosting: 638.3115421832"
## [21] "RMSE Gradient Boosting: 8941.58214707352"
## [22] "RMSE Gradient Boosting: 780.377875623017"
## [23] "RMSE Gradient Boosting: 1703.23112973031"
## [24] "RMSE Gradient Boosting: -1549.62672869914"
## [25] "RMSE Gradient Boosting: -1490.8034310344"
## [26] "RMSE Gradient Boosting: 6091.63666700424"
## [27] "RMSE Gradient Boosting: -1239.93415252982"
## [28] "RMSE Gradient Boosting: 3406.16494067367"
## [29] "RMSE Gradient Boosting: 3550.68651386553"
## [30] "RMSE Gradient Boosting: 154.062589856922"
## [31] "RMSE Gradient Boosting: 1755.06081488774"
## [32] "RMSE Gradient Boosting: 2688.29925168315"
## [33] "RMSE Gradient Boosting: 3148.08627203165"
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## [4554] "RMSE Gradient Boosting: 7037.85192878664"
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## [4608] "RMSE Gradient Boosting: 7795.99171551579"  
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## [4715] "RMSE Gradient Boosting: 14562.7855229565"

```

```

## [4716] "RMSE Gradient Boosting: -2417.78981126653"
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## [4747] "RMSE Gradient Boosting: 259.930791777635"
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```

```
## [4770] "RMSE Gradient Boosting: 775.873550373202"  
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## [4775] "RMSE Gradient Boosting: 502.970028572225"
```

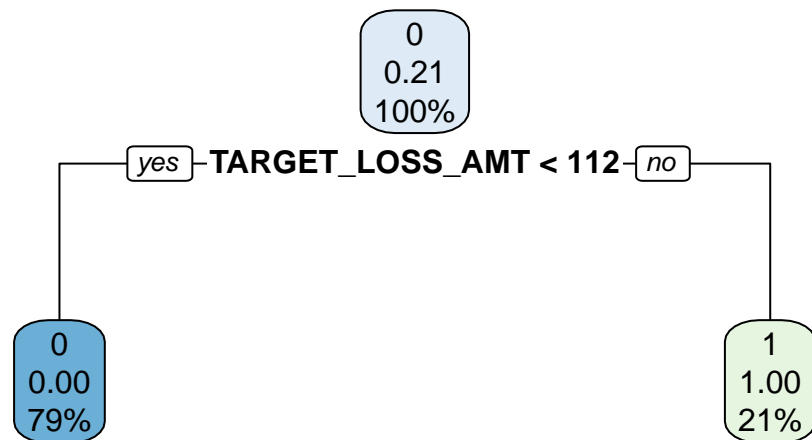
The trees all are optimal According to the results of my code, both decision trees are better than Random Forest and Gradient Boosting

#### Step-4

```
FLAG=sample(c(TRUE,FALSE), nrow(data), replace=TRUE, prob=c(0.7,0.3))  
data_train_s4=data[FLAG, ]  
data_test_s4=data[! FLAG, ]
```

```
tr_set=rpart.control(maxdepth=10)  
t1G1 = rpart(data=data_test_s4, TARGET_BAD_FLAG ~ ., control = tr_set, method = "class", parms = list(s
```

```
rpart.plot(t1G1)
```



1

```
t1G1$variable.importance
```

```
## TARGET_LOSS_AMT      M_DEBTINC      M_VALUE      IMP_DEBTINC      IMP_DELINQ
##      586.83475      134.08859      55.21295      45.74787      34.70528
##      IMP_DEROG
##      33.12777
```

```
rf_model <- randomForest(TARGET_BAD_FLAG ~ . - TARGET_LOSS_AMT, data = data_train_s4)
```

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

```
bad_flag_1_data <- data_train_s4[data_train_s4$TARGET_BAD_FLAG == 1, ]
```

```
tree_model <- rpart(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
rf_model_loss <- randomForest(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
gb_model_loss <- gbm(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data, n.trees = 1000, int
```

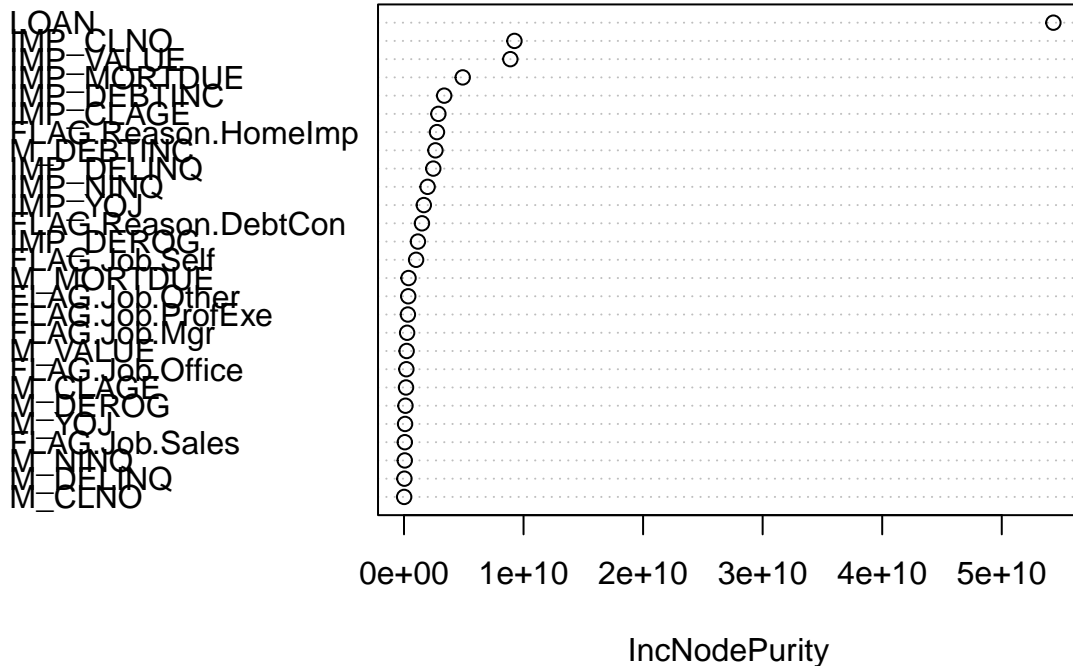
```
## Distribution not specified, assuming gaussian ...
```

```
varImpPlot(rf_model)
```





## rf\_model\_loss



```
prob_default <- predict(rf_model, data = data_test_s4, type = "response")
loss_given_default <- predict(rf_model_loss, data = data_test_s4, type = "response")
```

```
severity_model <- prob_default * loss_given_default
```

```
## Warning in prob_default * loss_given_default: longer object length is not a
## multiple of shorter object length
```

```
rmse <- sqrt(mean((data_test_s4$TARGET_LOSS_AMT - severity_model)^2))
```

```
## Warning in data_test_s4$TARGET_LOSS_AMT - severity_model: longer object length
## is not a multiple of shorter object length
```

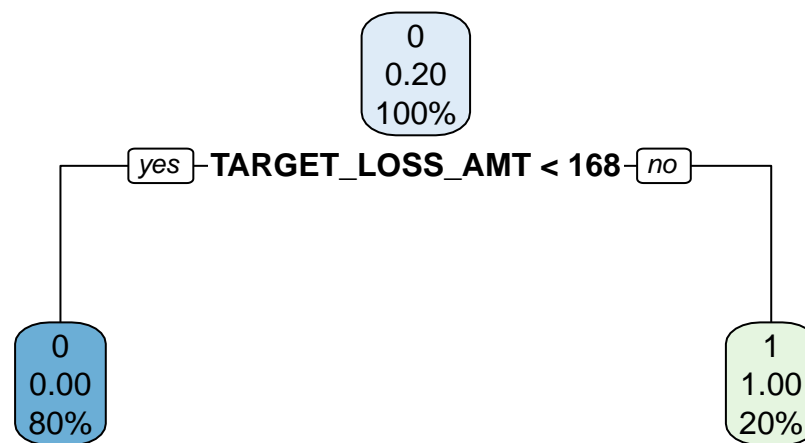
```
print(rmse)
```

```
## [1] 7979.374
```

```
FLAG=sample(c(TRUE,FALSE), nrow(data), replace=TRUE, prob=c(0.6,0.4))
data_train_s4=data[FLAG, ]
data_test_s4=data[! FLAG, ]
```

```
tr_set=rpart.control(maxdepth=10)
t1G1 = rpart(data=data_test_s4, TARGET_BAD_FLAG ~ ., control = tr_set, method = "class", parms = list(s
```

```
rpart.plot(t1G1)
```



2

```
t1G1$variable.importance
```

```
## TARGET_LOSS_AMT      M_DEBTINC      IMP_DELINQ      IMP_DEROG      M_VALUE
##      776.87732      199.81413      68.73606      67.13755      62.34201
##      IMP_DEBTINC
##      38.36431
```

```
rf_model <- randomForest(TARGET_BAD_FLAG ~ . - TARGET_LOSS_AMT, data = data_train_s4)
```

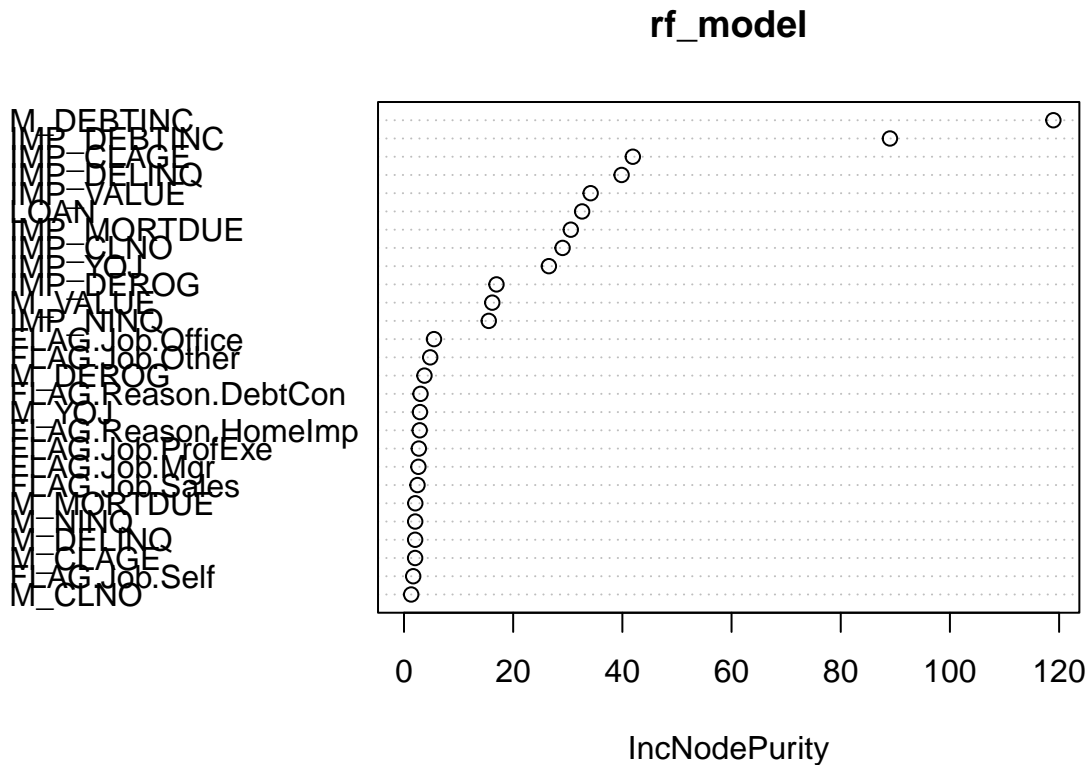
```
## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values. Are you sure you want to do regression?
```

```
bad_flag_1_data <- data_train_s4[data_train_s4$TARGET_BAD_FLAG == 1, ]
```

```
tree_model <- rpart(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
rf_model_loss <- randomForest(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
gb_model_loss <- gbm(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data, n.trees = 1000, int
```

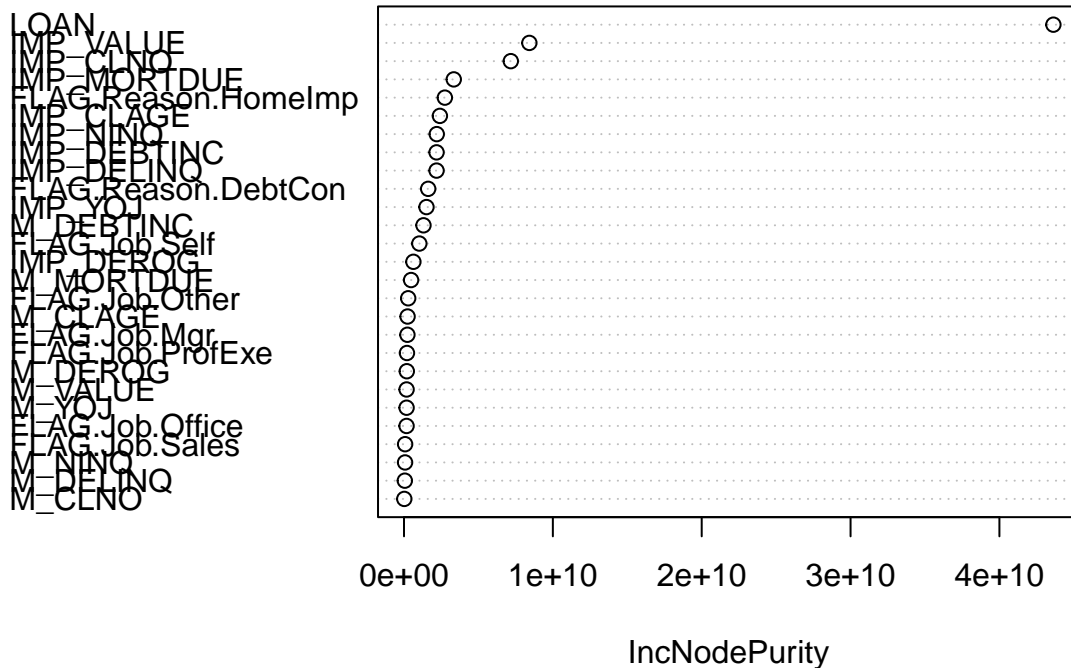
```
## Distribution not specified, assuming gaussian ...
```

```
varImpPlot(rf_model)
```



```
varImpPlot(rf_model_loss)
```

## rf\_model\_loss



```
prob_default <- predict(rf_model, data = data_test_s4, type = "response")
loss_given_default <- predict(rf_model_loss, data = data_test_s4, type = "response")
```

```
severity_model <- prob_default * loss_given_default
```

```
## Warning in prob_default * loss_given_default: longer object length is not a
## multiple of shorter object length
```

```
rmse <- sqrt(mean((data_test_s4$TARGET_LOSS_AMT - severity_model)^2))
```

```
## Warning in data_test_s4$TARGET_LOSS_AMT - severity_model: longer object length
## is not a multiple of shorter object length
```

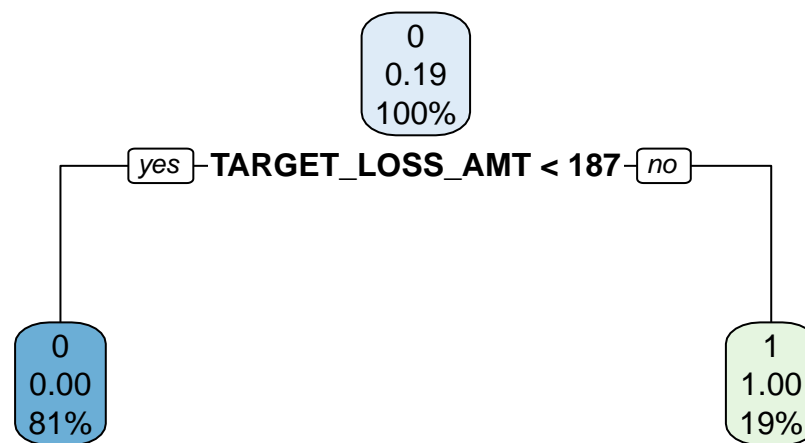
```
print(rmse)
```

```
## [1] 7755.6
```

```
FLAG=sample(c(TRUE,FALSE), nrow(data), replace=TRUE, prob=c(0.8,0.2))
data_train_s4=data[FLAG, ]
data_test_s4=data[! FLAG, ]
```

```
tr_set=rpart.control(maxdepth=10)
t1G1 = rpart(data=data_test_s4, TARGET_BAD_FLAG ~ ., control = tr_set, method = "class", parms = list(s
```

```
rpart.plot(t1G1)
```



3

```
t1G1$variable.importance
```

```
## TARGET_LOSS_AMT      M_DEBTINC      IMP_DEBTINC      M_VALUE      LOAN
##      350.92963      89.35708      29.24414      27.61946      21.12076
##      IMP_DEROG
##      19.49609
```

```
rf_model <- randomForest(TARGET_BAD_FLAG ~ . - TARGET_LOSS_AMT, data = data_train_s4)
```

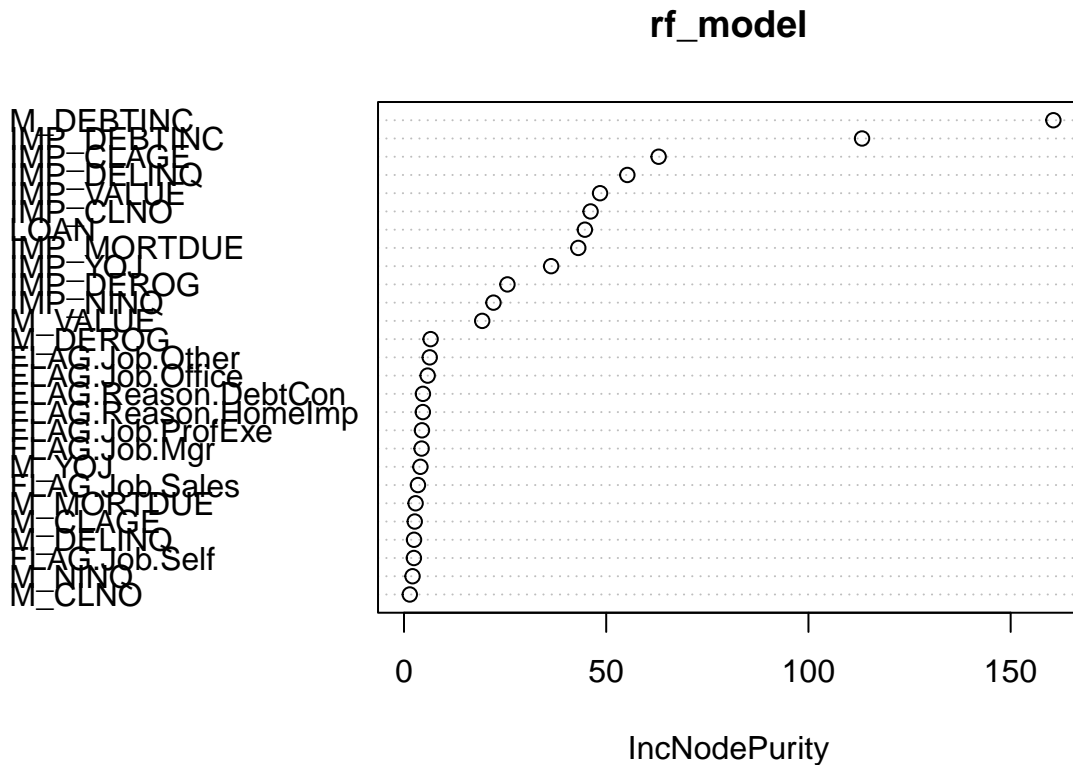
```
## Warning in randomForest.default(m, y, ...): The response has five or fewer
## unique values. Are you sure you want to do regression?
```

```
bad_flag_1_data <- data_train_s4[data_train_s4$TARGET_BAD_FLAG == 1, ]
```

```
tree_model <- rpart(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
rf_model_loss <- randomForest(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data)
gb_model_loss <- gbm(TARGET_LOSS_AMT ~ . - TARGET_BAD_FLAG, data = bad_flag_1_data, n.trees = 1000, int
```

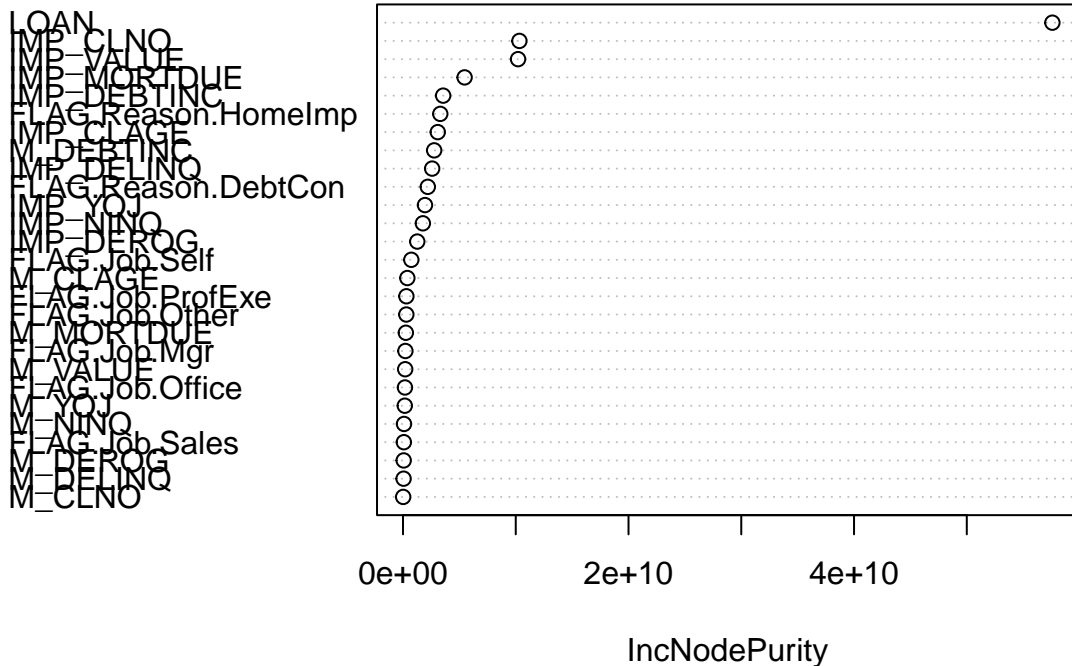
```
## Distribution not specified, assuming gaussian ...
```

```
varImpPlot(rf_model)
```



```
varImpPlot(rf_model_loss)
```

## rf\_model\_loss



```
prob_default <- predict(rf_model, data = data_test_s4, type = "response")
loss_given_default <- predict(rf_model_loss, data = data_test_s4, type = "response")
```

```
severity_model <- prob_default * loss_given_default
```

```
## Warning in prob_default * loss_given_default: longer object length is not a
## multiple of shorter object length
```

```
rmse <- sqrt(mean((data_test_s4$TARGET_LOSS_AMT - severity_model)^2))
```

```
## Warning in data_test_s4$TARGET_LOSS_AMT - severity_model: longer object length
## is not a multiple of shorter object length
```

```
print(rmse)
```

```
## [1] 8747.677
```

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