Predictive Modeling
Final Project
Direct Mail Fundraising Classification

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Introduction

The RStudio project files and accompanying artifacts, including the tex (Rnw) file that created this PDF, are publicly available on GitHub
`https://github.com/zollie/PASS-PredictiveModeling-DirectMailPrediction`

Preliminaries

The R code here is broken up into seperate scripts for general reuse and orginization. These are presented here, with full up to date versions available on GitHub

data.R

Contains functions and code to load, clean, and setup the data

```
> source('~/R/PASS/PredictiveModeling/DirectMailPrediction/data.R',
+        echo=TRUE, max.deparse.length=10000)

> set.seed(12345)

> getRandomRowNums <- function(dd = getDataRaw(), percent = 0.6) {
+     n <- nrow(dd)
+     a <- sort(sample(1:n, floor(n * percent)))
+     a
+ }

> getDataRaw <- function() {
+     dd <- read.csv("~/R/PASS/PredictiveModeling/DirectMailPrediction/DonorData.csv")
+ }

> getDataClean <- function(dd = getDataRaw()) {
```

```
+     dd$Row.Id <- NULL
+     dd$Row.Id. <- NULL
+     dd$row.names <- NULL
+     dd$TARGET_D <- NULL
+     dd
+ }

> getDataWithLevels <- function(dd = getDataClean()) {
+     dd$homeowner.dummy <- factor(dd$homeowner.dummy)
+     dd$gender.dummy <- factor(dd$gender.dummy)
+     dd$INCOME <- factor(dd$INCOME)
+     dd$WEALTH <- factor(dd$WEALTH)
+     dd$TARGET_B <- factor(dd$TARGET_B)
+     dd
+ }

> getNnData <- function(dd = getDataClean()) {
+     dd$WEALTH <- nnNormCol(dd$WEALTH)
+     dd$HV <- nnNormCol(dd$HV)
+     dd$lcmed <- nnNormCol(dd$Icmed)
+     dd$lcavg <- nnNormCol(dd$Icavg)
+     dd$IC15 <- nnNormCol(dd$IC15)
+     dd$NUMPROM <- nnNormCol(dd$NUMPROM)
+     dd$RAMNTALL <- nnNormCol(dd$RAMNTALL)
+     dd$MAXRAMNT <- nnNormCol(dd$MAXRAMNT)
+     dd$LASTGIFT <- nnNormCol(dd$LASTGIFT)
+     dd$totalmonths <- nnNormCol(dd$totalmonths)
+     dd$TIMELAG <- nnNormCol(dd$TIMELAG)
+     dd$AVGGIFT <- nnNormCol(dd$AVGGIFT)
+     dd
+ }

> getNnDataPruned <- function(dd = defaultReducePredictors(getDataClean())) {
+     dd$NUMPROM <- nnNormCol(dd$NUMPROM)
+     dd$RAMNTALL <- nnNormCol(dd$RAMNTALL)
+     dd$MAXRAMNT <- nnNormCol(dd$MAXRAMNT)
+     dd$LASTGIFT <- nnNormCol(dd$LASTGIFT)
+     dd$totalmonths <- nnNormCol(dd$totalmonths)
+     dd$TIMELAG <- nnNormCol(dd$TIMELAG)
+     dd
+ }

> nnNormCol <- function(col) {
+     a <- min(col, na.rm = TRUE)
+     b <- max(col, na.rm = TRUE)
+     c2 <- sapply(col, function(x) {
```

```
+         (x - a)/(b - a)
+     })
+     c2
+ }

> getFutureDataRaw <- function() {
+     dd <- read.csv("~/R/PASS/PredictiveModeling/DirectMailPrediction/FutureDonorData.csv")
+ }

> getFutureDataClean <- function(dd = getFutureDataRaw()) {
+     dd$Row.Id <- NULL
+     dd$Row.Id. <- NULL
+     dd$X <- NULL
+     dd$X.1 <- NULL
+     dd$X.2 <- NULL
+     dd$X.3 <- NULL
+     dd$X.4 <- NULL
+     dd$X.5 <- NULL
+     dd$X.6 <- NULL
+     dd
+ }

> getFutureDataWithLevels <- function(dd = getFutureDataClean()) {
+     dd$homeowner.dummy <- factor(dd$homeowner.dummy)
+     dd$gender.dummy <- factor(dd$gender.dummy)
+     dd$INCOME <- factor(dd$INCOME)
+     dd$WEALTH <- factor(dd$WEALTH)
+     dd
+     dd
+ }

> reducePredictors <- function(dd = getDataWithLevels(),
+     drops) {
+     dd[, !(names(dd) %in% drops)]
+ }

> defaultReducePredictors <- function(dd = getDataWithLevels()) {
+     drops <- c("zipconvert_2", "zipconvert_3", "zipconvert_4",
+         "zipconvert_5", "WEALTH", "HV", "Icmed", "Icavg", "IC15",
+         "AVGGIFT")
+     reducePredictors(dd, drops)
+ }

> prices <- matrix(c(0, 0, -0.68, 13 - 0.68), 2, 2)
```

funcs.R

Contains helper functions and code to build classification tables, charts, calculate lift, etc.

```
> source('~/R/PASS/PredictiveModeling/DirectMailPrediction/funcs.R',
+        echo=TRUE, max.deparse.length=10000)

> buildClassTab <- function(p, p.target, cutoff = 0.5) {
+     require(gmodels)
+     if (is.null(cutoff)) {
+         p.vals = p
+     }
+     else {
+         p.vals <- sapply(p, function(y) {
+             ifelse(y < cutoff, 0, 1)
+         })
+     }
+     CrossTable(p.target, p.vals, type = "SPSS", dnn = c("Actual",
+         "Predicted"))
+ }

> drawRoc <- function(p, p.target) {
+     require(ROCR)
+     p.rocr <- prediction(p, p.target)
+     p.rocr.roc <- performance(p.rocr, "tpr", "fpr")
+     plot(p.rocr.roc, main = "ROC Curve", colorize = T)
+ }

> drawLift <- function(p, p.target, add = FALSE) {
+     require(ROCR)
+     p.rocr <- prediction(p, p.target)
+     p.rocr.lift <- performance(p.rocr, "lift", "rpp")
+     plot(p.rocr.lift, add = add, main = "Lift Curve", colorize = T)
+ }

> adjustTabForOversamp <- function(ct, target, dnn = c("Actual",
+     "Predicted")) {
+     t <- ct$t
+     actual.0 <- t[1, 1] + t[1, 2]
+     actual.1 <- t[2, 1] + t[2, 2]
+     prop.0 <- 1 - target
+     n <- target * 100
+     x <- actual.1 * 100/n
+     new.0 <- x * prop.0
+     ct
+     x.0 <- ct$prop.row[1, 1] * new.0
```

```
+     x.1 <- ct$prop.row[1, 2] * new.0
+     row1 <- matrix(c(x.0, x.1), 1, 2)
+     row2 <- matrix(c(t[2, 1], t[2, 2]), 1, 2)
+     df <- rbind(row1, row2)
+     CrossTable(df, dnn = dnn)
+ }

> netFromCrossTab <- function(ct, prices) {
+     t <- ct$t
+     x00 <- t[1, 1] * prices[1, 1]
+     x01 <- t[1, 2] * prices[1, 2]
+     x10 <- t[2, 1] * prices[2, 1]
+     x11 <- t[2, 2] * prices[2, 2]
+     sum(x00, x01, x10, x11)
+ }

> buildClassTree <- function(formula, data, minspl,
+     minbuc) {
+     require(rpart)
+     tree.g <- rpart(formula, data = data, method = "class", minsplit = minspl,
+         minbucket = minbuc)
+     tree.p <- prune(tree.g, tree.g$cptable[which.min(tree.g$cptable[,
+         "xerror"]), "CP"])
+     tree.p
+ }
```

Data Setup

Factorized data will be used for Logistic Regression and CART

```
> dd <- getDataWithLevels()
> n <- getRandomRowNums(dd)
> dd.train <- dd[n,]
> dd.test <- dd[-n,]
```

Model Building (a)

Logistic Regression

Logistic Regression is applied here with varying parameters and predictors used. For each continuos predictor, ROC and Lift curves will be generated to compare the models.

Using all predictors available

```
> logit <- glm(TARGET_B ~ ., family=binomial("logit"), data=dd.train)
> summary(logit)

Call:
glm(formula = TARGET_B ~ ., family = binomial("logit"), data = dd.train)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.7805  -1.1485  -0.7362   1.1463   2.1338

Coefficients:
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)      -1.230e+01  3.032e+02  -0.041   0.9676
zipconvert_2      1.377e+01  3.032e+02   0.045   0.9638
zipconvert_3      1.371e+01  3.032e+02   0.045   0.9639
zipconvert_4      1.359e+01  3.032e+02   0.045   0.9643
zipconvert_5      1.371e+01  3.032e+02   0.045   0.9639
homeowner.dummy1  1.003e-01  1.248e-01   0.804   0.4214
NUMCHLD          -2.880e-01  1.384e-01  -2.080   0.0375 *
INCOME2           2.473e-01  1.971e-01   1.255   0.2095
INCOME3           2.626e-01  2.202e-01   1.193   0.2330
INCOME4           2.696e-01  1.842e-01   1.463   0.1435
INCOME5           4.806e-01  2.000e-01   2.404   0.0162 *
INCOME6           4.425e-01  2.426e-01   1.824   0.0681 .
INCOME7           5.585e-01  2.446e-01   2.283   0.0224 *
gender.dummy1     8.441e-02  9.826e-02   0.859   0.3903
WEALTH1           5.375e-01  3.366e-01   1.597   0.1103
WEALTH2          -1.835e-01  3.401e-01  -0.539   0.5896
WEALTH3           6.874e-02  3.207e-01   0.214   0.8303
WEALTH4           9.754e-02  3.364e-01   0.290   0.7718
WEALTH5           9.023e-02  3.247e-01   0.278   0.7811
WEALTH6           2.486e-01  3.333e-01   0.746   0.4557
WEALTH7           2.608e-01  3.417e-01   0.763   0.4452
WEALTH8           2.230e-01  2.733e-01   0.816   0.4145
WEALTH9           2.012e-01  3.321e-01   0.606   0.5445
HV                1.275e-04  8.931e-05   1.427   0.1535
Icmed             6.478e-04  1.178e-03   0.550   0.5823
Icavg            -1.050e-03  1.285e-03  -0.817   0.4137
IC15              2.495e-03  5.825e-03   0.428   0.6684
NUMPROM           4.976e-03  3.569e-03   1.394   0.1633
RAMNTALL         -2.677e-04  6.930e-04  -0.386   0.6993
MAXRAMNT          4.317e-03  7.309e-03   0.591   0.5548
LASTGIFT         -2.264e-02  1.103e-02  -2.053   0.0401 *
totalmonths      -5.774e-02  1.303e-02  -4.432 9.34e-06 ***
TIMELAG           6.191e-03  8.838e-03   0.701   0.4836
```

```
AVGGIFT          6.560e-03  1.560e-02   0.420   0.6741
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2595.1  on 1871  degrees of freedom
Residual deviance: 2518.7  on 1838  degrees of freedom
AIC: 2586.7

Number of Fisher Scoring iterations: 12
```

Prediction Prediction using the test data is done with the model and evaluated using ROC and Lift curves.

```
> logit.pred <- predict(logit, newdata=dd.test, type="response")
> summary(logit.pred)

     Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
0.0000009 0.4371000 0.5024000 0.5013000 0.5597000 0.8394000
```

Evaluation Clearly, this model is not much better than the Naive Rule.

Subset Selection Predictor reduction was attempted but in no case did the ROC curve suggest significantly better results than the Naive Rule. Attempting each predictor one by one also faired no better. The best predictor using Logistic Regression perhaps being LASTGIFT.

```
> logit.lg <- glm(TARGET_B ~ LASTGIFT, family = binomial("logit"), data = dd.train)
> logit.lg.pred <- predict(logit.lg, newdata=dd.test, type="response")
```

Classification Table and Net Profit Classifcation Tables and NetProfit using this model is presented here

```
> ct.logit.lg <- buildClassTab(logit.lg.pred, dd.test$TARGET_B)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|
```

```
> drawRoc(logit.pred, dd.test$TARGET_B)
```

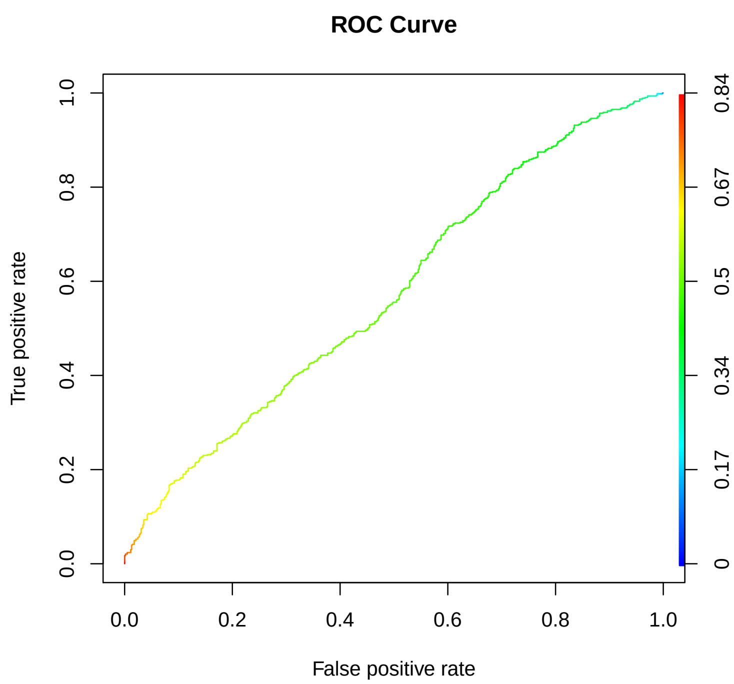


Figure 1: Logistic Regression ROC curve using all predictors

```
> drawLift(logit.pred, dd.test$TARGET_B)
```

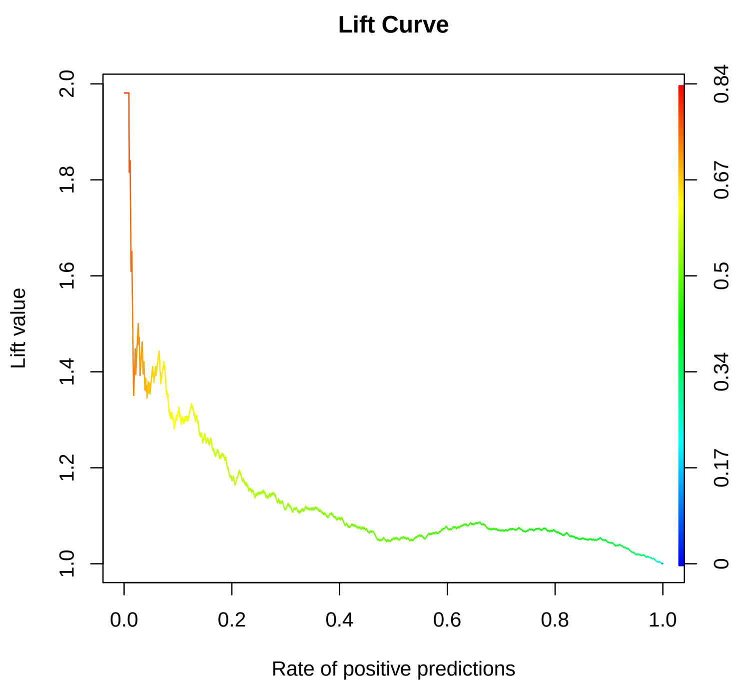


Figure 2: Logistic Regression Lift curve using all predictors

```
> drawRoc(logit.lg.pred, dd.test$TARGET_B)
```

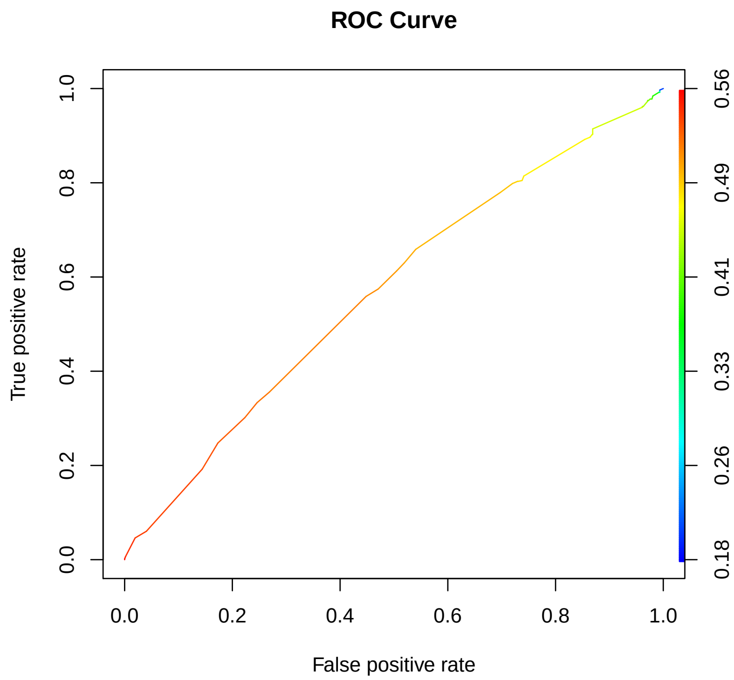


Figure 3: Logistic Regression ROC curve using only LASTGIFT

```
Total Observations in Table:  1248


             | Predicted
      Actual |         0 |         1 | Row Total |
-------------|-----------|-----------|-----------|
           0 |       306 |       312 |       618 |
             |     4.156 |     3.275 |           |
             |     0.495 |     0.505 |     0.495 |
             |     0.556 |     0.447 |           |
             |     0.245 |     0.250 |           |
-------------|-----------|-----------|-----------|
           1 |       244 |       386 |       630 |
             |     4.077 |     3.212 |           |
             |     0.387 |     0.613 |     0.505 |
             |     0.444 |     0.553 |           |
             |     0.196 |     0.309 |           |
-------------|-----------|-----------|-----------|
Column Total |       550 |       698 |      1248 |
             |     0.441 |     0.559 |           |
-------------|-----------|-----------|-----------|
```

```
> ct.logit.lg.a <- adjustTabForOversamp(ct.logit.lg, .051)
```

```
   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  12352.94


             | Predicted
      Actual |              [,1] |              [,2] |         Row Total |
-------------|-------------------|-------------------|-------------------|
        [1,] |              5804 |              5918 |             11722 |
             |             0.724 |             0.695 |                   |
             |             0.495 |             0.505 |             0.949 |
             |             0.960 |             0.939 |                   |
             |             0.470 |             0.479 |                   |
```

```
-------------|------------------|------------------|------------------|
       [2,] |              244 |              386 |              630 |
            |           13.477 |           12.930 |                  |
            |            0.387 |            0.613 |            0.051 |
            |            0.040 |            0.061 |                  |
            |            0.020 |            0.031 |                  |
-------------|------------------|------------------|------------------|
Column Total |             6048 |             6304 |            12352 |
            |            0.490 |            0.510 |                  |
-------------|------------------|------------------|------------------|
```

```
> ct.logit.net <- netFromCrossTab(ct.logit.lg.a, prices)
> ct.logit.net
```

```
[1] 731.0229
```

CART

Classification Trees are attempted next

```
> library(rpart.plot)
> tree.a <- buildClassTree(TARGET_B ~ ., dd.train, 3, 1)
> tree.b <- buildClassTree(TARGET_B ~ ., dd.train, 6, 2)
> tree.c <- buildClassTree(TARGET_B ~ ., dd.train, 12, 4)
> summary(tree.a)
```

```
Call:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)
  n= 1872

          CP nsplit rel error    xerror       xstd
1 0.12473118      0 1.0000000 1.0397849 0.02324886
2 0.01048387      1 0.8752688 0.9268817 0.02318881

Variable importance
    AVGGIFT    MAXRAMNT    LASTGIFT totalmonths     NUMPROM    RAMNTALL
         35          25          24           8           5           3

Node number 1: 1872 observations,    complexity param=0.1247312
  predicted class=0  expected loss=0.4967949  P(node) =1
    class counts:   942   930
   probabilities: 0.503 0.497
  left son=2 (832 obs) right son=3 (1040 obs)
  Primary splits:
      AVGGIFT     < 9.878676 to the right, improve=16.276920, (0 missing)
      totalmonths < 31.5     to the right, improve=14.088780, (0 missing)
```

```
      MAXRAMNT    < 14.5     to the right, improve=13.134850, (0 missing)
      LASTGIFT    < 14.5     to the right, improve=12.963660, (0 missing)
      NUMPROM     < 54.5     to the left,  improve= 8.441558, (0 missing)
  Surrogate splits:
      MAXRAMNT    < 14.5     to the right, agree=0.876, adj=0.720, (0 split)
      LASTGIFT    < 12.5     to the right, agree=0.857, adj=0.679, (0 split)
      totalmonths < 35.5     to the right, agree=0.659, adj=0.232, (0 split)
      NUMPROM     < 24.5     to the left,  agree=0.624, adj=0.155, (0 split)
      RAMNTALL    < 26.5     to the left,  agree=0.596, adj=0.091, (0 split)

Node number 2: 832 observations
  predicted class=0  expected loss=0.4230769  P(node) =0.4444444
    class counts:   480   352
   probabilities: 0.577 0.423

Node number 3: 1040 observations
  predicted class=1  expected loss=0.4442308  P(node) =0.5555556
    class counts:   462   578
   probabilities: 0.444 0.556

> printcp(tree.a)

Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT

Root node error: 930/1872 = 0.49679

n= 1872

        CP nsplit rel error  xerror     xstd
1 0.124731      0   1.00000 1.03978 0.023249
2 0.010484      1   0.87527 0.92688 0.023189

> rsq.rpart(tree.a)

Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT

Root node error: 930/1872 = 0.49679
```

```
> prp(tree.a)
```

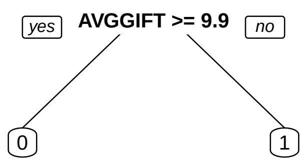


Figure 4: tree.a classification tree

```
n= 1872

        CP nsplit rel error  xerror     xstd
1 0.124731      0   1.00000 1.03978 0.023249
2 0.010484      1   0.87527 0.92688 0.023189


> tree.a.pred <- predict(tree.a, newdata=dd.test, type="class")
> ct.tree.a <- buildClassTab(tree.a.pred, dd.test$TARGET_B, cutoff=NULL)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
```

```
|         N / Table Total |
|-------------------------|


Total Observations in Table:  1248


             | Predicted
      Actual |         0 |         1 | Row Total |
-------------|-----------|-----------|-----------|
           0 |       296 |       322 |       618 |
             |     2.733 |     2.105 |           |
             |     0.479 |     0.521 |     0.495 |
             |     0.545 |     0.457 |           |
             |     0.237 |     0.258 |           |
-------------|-----------|-----------|-----------|
           1 |       247 |       383 |       630 |
             |     2.681 |     2.065 |           |
             |     0.392 |     0.608 |     0.505 |
             |     0.455 |     0.543 |           |
             |     0.198 |     0.307 |           |
-------------|-----------|-----------|-----------|
Column Total |       543 |       705 |      1248 |
             |     0.435 |     0.565 |           |
-------------|-----------|-----------|-----------|

> ct.tree.a.a <- adjustTabForOversamp(ct.tree.a, .051)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  12352.94


             | Predicted
      Actual |               [,1] |               [,2] |          Row Total |
-------------|--------------------|--------------------|--------------------|
        [1,] |               5614 |               6108 |              11722 |
             |              0.485 |              0.438 |                    |
```

```
             |            0.479 |            0.521 |            0.949 |
             |            0.958 |            0.941 |                  |
             |            0.455 |            0.494 |                  |
-------------|------------------|------------------|------------------|
        [2,] |              247 |              383 |              630 |
             |            9.029 |            8.154 |                  |
             |            0.392 |            0.608 |            0.051 |
             |            0.042 |            0.059 |                  |
             |            0.020 |            0.031 |                  |
-------------|------------------|------------------|------------------|
Column Total |             5861 |             6491 |            12352 |
             |            0.475 |            0.525 |                  |
-------------|------------------|------------------|------------------|
```

```
> net.tree.a <- netFromCrossTab(ct.tree.a.a, prices)
> net.tree.a
```

```
[1] 565.0726
```

```
> summary(tree.b)
```

```
Call:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)
  n= 1872

          CP nsplit rel error    xerror       xstd
1 0.12473118      0 1.0000000 1.0559140 0.02323351
2 0.01048387      1 0.8752688 0.9043011 0.02314150

Variable importance
    AVGGIFT    MAXRAMNT    LASTGIFT totalmonths     NUMPROM    RAMNTALL
         35          25          24           8           5           3

Node number 1: 1872 observations,    complexity param=0.1247312
  predicted class=0  expected loss=0.4967949  P(node) =1
    class counts:   942   930
   probabilities: 0.503 0.497
  left son=2 (832 obs) right son=3 (1040 obs)
  Primary splits:
      AVGGIFT     < 9.878676 to the right, improve=16.276920, (0 missing)
      totalmonths < 31.5     to the right, improve=14.088780, (0 missing)
      MAXRAMNT    < 14.5     to the right, improve=13.134850, (0 missing)
      LASTGIFT    < 14.5     to the right, improve=12.963660, (0 missing)
      NUMPROM     < 54.5     to the left,  improve= 8.441558, (0 missing)
  Surrogate splits:
      MAXRAMNT    < 14.5     to the right, agree=0.876, adj=0.720, (0 split)
```

```
      LASTGIFT    < 12.5     to the right, agree=0.857, adj=0.679, (0 split)
      totalmonths < 35.5     to the right, agree=0.659, adj=0.232, (0 split)
      NUMPROM     < 24.5     to the left,  agree=0.624, adj=0.155, (0 split)
      RAMNTALL    < 26.5     to the left,  agree=0.596, adj=0.091, (0 split)

Node number 2: 832 observations
  predicted class=0  expected loss=0.4230769  P(node) =0.4444444
    class counts:   480   352
   probabilities: 0.577 0.423

Node number 3: 1040 observations
  predicted class=1  expected loss=0.4442308  P(node) =0.5555556
    class counts:   462   578
   probabilities: 0.444 0.556
```

> printcp(tree.b)

```
Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT

Root node error: 930/1872 = 0.49679

n= 1872

        CP nsplit rel error xerror     xstd
1 0.124731      0   1.00000 1.0559 0.023234
2 0.010484      1   0.87527 0.9043 0.023141
```

> rsq.rpart(tree.b)

```
Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT

Root node error: 930/1872 = 0.49679

n= 1872

        CP nsplit rel error xerror     xstd
1 0.124731      0   1.00000 1.0559 0.023234
2 0.010484      1   0.87527 0.9043 0.023141
```

```
> prp(tree.b)
```

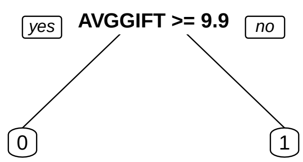


Figure 5: tree.b classification tree

```
> tree.b.pred <- predict(tree.b, newdata=dd.test, type="class")
> ct.tree.b <- buildClassTab(tree.b.pred, dd.test$TARGET_B, cutoff=NULL)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  1248


             | Predicted
```

```
      Actual |         0 |         1 | Row Total |
-------------|-----------|-----------|-----------|
           0 |       296 |       322 |       618 |
             |     2.733 |     2.105 |           |
             |     0.479 |     0.521 |     0.495 |
             |     0.545 |     0.457 |           |
             |     0.237 |     0.258 |           |
-------------|-----------|-----------|-----------|
           1 |       247 |       383 |       630 |
             |     2.681 |     2.065 |           |
             |     0.392 |     0.608 |     0.505 |
             |     0.455 |     0.543 |           |
             |     0.198 |     0.307 |           |
-------------|-----------|-----------|-----------|
Column Total |       543 |       705 |      1248 |
             |     0.435 |     0.565 |           |
-------------|-----------|-----------|-----------|
```

```
> ct.tree.b.a <- adjustTabForOversamp(ct.tree.b, .051)
```

```
   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  12352.94


             | Predicted
      Actual |              [,1] |              [,2] |         Row Total |
-------------|-------------------|-------------------|-------------------|
        [1,] |              5614 |              6108 |             11722 |
             |             0.485 |             0.438 |                   |
             |             0.479 |             0.521 |             0.949 |
             |             0.958 |             0.941 |                   |
             |             0.455 |             0.494 |                   |
-------------|-------------------|-------------------|-------------------|
        [2,] |               247 |               383 |               630 |
             |             9.029 |             8.154 |                   |
             |             0.392 |             0.608 |             0.051 |
             |             0.042 |             0.059 |                   |
```

```
             |            0.020 |            0.031 |                  |
-------------|------------------|------------------|------------------|
Column Total |             5861 |             6491 |            12352 |
             |            0.475 |            0.525 |                  |
-------------|------------------|------------------|------------------|

> net.tree.b <- netFromCrossTab(ct.tree.b.a, prices)
> net.tree.b

[1] 565.0726

> tree.c.pred <- predict(tree.c, newdata=dd.test, type="class")
> ct.tree.c <- buildClassTab(tree.c.pred, dd.test$TARGET_B, cutoff=NULL)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  1248


             | Predicted
      Actual |         0 |         1 | Row Total |
-------------|-----------|-----------|-----------|
           0 |       225 |       393 |       618 |
             |     2.158 |     1.063 |           |
             |     0.364 |     0.636 |     0.495 |
             |     0.546 |     0.470 |           |
             |     0.180 |     0.315 |           |
-------------|-----------|-----------|-----------|
           1 |       187 |       443 |       630 |
             |     2.117 |     1.043 |           |
             |     0.297 |     0.703 |     0.505 |
             |     0.454 |     0.530 |           |
             |     0.150 |     0.355 |           |
-------------|-----------|-----------|-----------|
Column Total |       412 |       836 |      1248 |
             |     0.330 |     0.670 |           |
-------------|-----------|-----------|-----------|

> ct.tree.c.a <- adjustTabForOversamp(ct.tree.c, .051)
```

```
   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  12352.94


             | Predicted
      Actual |              [,1] |              [,2] |         Row Total |
-------------|-------------------|-------------------|-------------------|
        [1,] |              4268 |              7454 |             11722 |
             |             0.382 |             0.216 |                   |
             |             0.364 |             0.636 |             0.949 |
             |             0.958 |             0.944 |                   |
             |             0.346 |             0.603 |                   |
-------------|-------------------|-------------------|-------------------|
        [2,] |               187 |               443 |               630 |
             |             7.115 |             4.014 |                   |
             |             0.297 |             0.703 |             0.051 |
             |             0.042 |             0.056 |                   |
             |             0.015 |             0.036 |                   |
-------------|-------------------|-------------------|-------------------|
Column Total |              4455 |              7897 |             12352 |
             |             0.361 |             0.639 |                   |
-------------|-------------------|-------------------|-------------------|
```

```
> net.tree.c <- netFromCrossTab(ct.tree.c.a, prices)
> net.tree.c
```

```
[1] 388.4416
```

```
> summary(tree.c)
```

```
Call:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)
  n= 1872

          CP nsplit rel error    xerror       xstd
1 0.12473118      0 1.0000000 1.0290323 0.02325577
2 0.01048387      1 0.8752688 0.9193548 0.02317436
```

```
3 0.01000000      5 0.8333333 0.9021505 0.02313637

Variable importance
    AVGGIFT    MAXRAMNT    LASTGIFT     NUMPROM totalmonths      INCOME
         22          17          16          13          11           8
     WEALTH    RAMNTALL     TIMELAG
          7           5           2

Node number 1: 1872 observations,    complexity param=0.1247312
  predicted class=0  expected loss=0.4967949  P(node) =1
    class counts:   942   930
   probabilities: 0.503 0.497
  left son=2 (832 obs) right son=3 (1040 obs)
  Primary splits:
      AVGGIFT     < 9.878676 to the right, improve=16.276920, (0 missing)
      totalmonths < 31.5     to the right, improve=14.088780, (0 missing)
      MAXRAMNT    < 14.5     to the right, improve=13.134850, (0 missing)
      LASTGIFT    < 14.5     to the right, improve=12.963660, (0 missing)
      NUMPROM     < 54.5     to the left,  improve= 8.441558, (0 missing)
  Surrogate splits:
      MAXRAMNT    < 14.5     to the right, agree=0.876, adj=0.720, (0 split)
      LASTGIFT    < 12.5     to the right, agree=0.857, adj=0.679, (0 split)
      totalmonths < 35.5     to the right, agree=0.659, adj=0.232, (0 split)
      NUMPROM     < 24.5     to the left,  agree=0.624, adj=0.155, (0 split)
      RAMNTALL    < 26.5     to the left,  agree=0.596, adj=0.091, (0 split)

Node number 2: 832 observations,    complexity param=0.01048387
  predicted class=0  expected loss=0.4230769  P(node) =0.4444444
    class counts:   480   352
   probabilities: 0.577 0.423
  left son=4 (823 obs) right son=5 (9 obs)
  Primary splits:
      NUMPROM     < 118      to the left,  improve=6.056641, (0 missing)
      INCOME      splits as  LLRRRRR,      improve=4.468691, (0 missing)
      Icmed       < 163.5    to the left,  improve=4.277984, (0 missing)
      WEALTH      splits as  RRLRLLRRRR,   improve=3.714286, (0 missing)
      totalmonths < 31.5     to the right, improve=3.479007, (0 missing)
  Surrogate splits:
      MAXRAMNT < 132.5    to the left,  agree=0.99, adj=0.111, (0 split)

Node number 3: 1040 observations
  predicted class=1  expected loss=0.4442308  P(node) =0.5555556
    class counts:   462   578
   probabilities: 0.444 0.556

Node number 4: 823 observations,    complexity param=0.01048387
```

```
  predicted class=0  expected loss=0.4167679  P(node) =0.4396368
    class counts:   480   343
   probabilities: 0.583 0.417
  left son=8 (161 obs) right son=9 (662 obs)
  Primary splits:
      INCOME splits as  LLRRRRR,      improve=5.633731, (0 missing)
      Icmed  < 158      to the left,  improve=5.307601, (0 missing)
      WEALTH splits as  RRLRLLRRRR,   improve=3.709045, (0 missing)
      Icavg  < 174.5    to the left,  improve=3.161087, (0 missing)
      HV     < 252.5    to the left,  improve=3.051052, (0 missing)
  Surrogate splits:
      IC15 < 54.5     to the right, agree=0.806, adj=0.006, (0 split)

Node number 5: 9 observations
  predicted class=1  expected loss=0  P(node) =0.004807692
    class counts:     0     9
   probabilities: 0.000 1.000

Node number 8: 161 observations
  predicted class=0  expected loss=0.2981366  P(node) =0.08600427
    class counts:   113    48
   probabilities: 0.702 0.298

Node number 9: 662 observations,    complexity param=0.01048387
  predicted class=0  expected loss=0.4456193  P(node) =0.3536325
    class counts:   367   295
   probabilities: 0.554 0.446
  left son=18 (373 obs) right son=19 (289 obs)
  Primary splits:
      totalmonths < 31.5     to the right, improve=4.075566, (0 missing)
      Icmed       < 158      to the left,  improve=4.032445, (0 missing)
      WEALTH      splits as  RRLRLLLLRL,   improve=3.630847, (0 missing)
      IC15        < 7.5      to the left,  improve=3.278974, (0 missing)
      HV          < 251      to the left,  improve=2.809783, (0 missing)
  Surrogate splits:
      LASTGIFT < 14.5     to the right, agree=0.636, adj=0.166, (0 split)
      RAMNTALL < 100.5    to the left,  agree=0.627, adj=0.145, (0 split)
      TIMELAG  < 4.5      to the right, agree=0.612, adj=0.111, (0 split)
      MAXRAMNT < 13.5     to the right, agree=0.594, adj=0.069, (0 split)
      NUMPROM  < 85.5     to the left,  agree=0.591, adj=0.062, (0 split)

Node number 18: 373 observations
  predicted class=0  expected loss=0.3967828  P(node) =0.1992521
    class counts:   225   148
   probabilities: 0.603 0.397
```

```
Node number 19: 289 observations,    complexity param=0.01048387
  predicted class=1  expected loss=0.4913495  P(node) =0.1543803
    class counts:   142   147
   probabilities: 0.491 0.509
  left son=38 (101 obs) right son=39 (188 obs)
  Primary splits:
      WEALTH   splits as  RRLRLLLLRL,   improve=5.444424, (0 missing)
      MAXRAMNT < 21.5     to the right, improve=3.806479, (0 missing)
      RAMNTALL < 69.5     to the right, improve=3.425653, (0 missing)
      NUMPROM  < 23.5     to the right, improve=2.697049, (0 missing)
      LASTGIFT < 22.5     to the right, improve=2.120607, (0 missing)
  Surrogate splits:
      RAMNTALL    < 124      to the right, agree=0.744, adj=0.267, (0 split)
      NUMPROM     < 40.5     to the right, agree=0.730, adj=0.228, (0 split)
      TIMELAG     < 10.5     to the right, agree=0.696, adj=0.129, (0 split)
      IC15        < 2.5      to the left,  agree=0.664, adj=0.040, (0 split)
      totalmonths < 17.5     to the left,  agree=0.661, adj=0.030, (0 split)

Node number 38: 101 observations
  predicted class=0  expected loss=0.3762376  P(node) =0.05395299
    class counts:    63    38
   probabilities: 0.624 0.376

Node number 39: 188 observations
  predicted class=1  expected loss=0.4202128  P(node) =0.1004274
    class counts:    79   109
   probabilities: 0.420 0.580
```

> *printcp(tree.c)*

```
Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT     INCOME      NUMPROM     totalmonths WEALTH

Root node error: 930/1872 = 0.49679

n= 1872

        CP nsplit rel error  xerror     xstd
1 0.124731      0   1.00000 1.02903 0.023256
2 0.010484      1   0.87527 0.91935 0.023174
3 0.010000      5   0.83333 0.90215 0.023136
```

> *rsq.rpart(tree.c)*

> prp(tree.c)

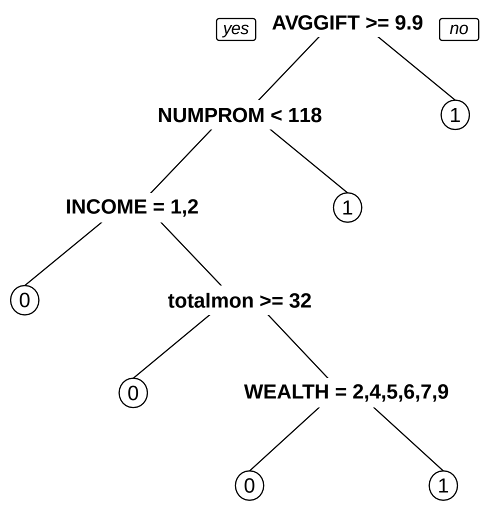


Figure 6: tree.c classification tree

```
Classification tree:
rpart(formula = formula, data = data, method = "class", minsplit = minspl,
    minbucket = minbuc)

Variables actually used in tree construction:
[1] AVGGIFT     INCOME      NUMPROM     totalmonths WEALTH

Root node error: 930/1872 = 0.49679

n= 1872

        CP nsplit rel error  xerror     xstd
1 0.124731      0   1.00000 1.02903 0.023256
2 0.010484      1   0.87527 0.91935 0.023174
3 0.010000      5   0.83333 0.90215 0.023136
```

```
> tree.c.pred <- predict(tree.c, newdata=dd.test, type="class")
> ct.tree.c <- buildClassTab(tree.c.pred, dd.test$TARGET_B, cutoff=NULL)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  1248


             | Predicted
      Actual |         0 |         1 | Row Total |
-------------|-----------|-----------|-----------|
           0 |       225 |       393 |       618 |
             |     2.158 |     1.063 |           |
             |     0.364 |     0.636 |     0.495 |
             |     0.546 |     0.470 |           |
             |     0.180 |     0.315 |           |
-------------|-----------|-----------|-----------|
           1 |       187 |       443 |       630 |
             |     2.117 |     1.043 |           |
             |     0.297 |     0.703 |     0.505 |
             |     0.454 |     0.530 |           |
             |     0.150 |     0.355 |           |
-------------|-----------|-----------|-----------|
Column Total |       412 |       836 |      1248 |
             |     0.330 |     0.670 |           |
-------------|-----------|-----------|-----------|

> ct.tree.c.a <- adjustTabForOversamp(ct.tree.c, .051)

   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|
```

```
Total Observations in Table:  12352.94


             | Predicted
      Actual |              [,1] |              [,2] |         Row Total |
-------------|-------------------|-------------------|-------------------|
        [1,] |              4268 |              7454 |             11722 |
             |             0.382 |             0.216 |                   |
             |             0.364 |             0.636 |             0.949 |
             |             0.958 |             0.944 |                   |
             |             0.346 |             0.603 |                   |
-------------|-------------------|-------------------|-------------------|
        [2,] |               187 |               443 |               630 |
             |             7.115 |             4.014 |                   |
             |             0.297 |             0.703 |             0.051 |
             |             0.042 |             0.056 |                   |
             |             0.015 |             0.036 |                   |
-------------|-------------------|-------------------|-------------------|
Column Total |              4455 |              7897 |             12352 |
             |             0.361 |             0.639 |                   |
-------------|-------------------|-------------------|-------------------|
```

```
> net.tree.c <- netFromCrossTab(ct.tree.c.a, prices)
> net.tree.c
```

```
[1] 388.4416
```

Neural Networks

The data for a Neural Net needs to be prepared so that the predictors are in the range of [0:1]. Using all predictors resulted in a ROC curve nearly equal to that of the Naive Rule. Therefore, domain knowledge provided by the case writeup was used to prune predictors

```
> library(nnet)
> ddn <- getNnDataPruned()
> n <- getRandomRowNums()
> ddn.train <- ddn[n,]
> ddn.test <- ddn[-n,]
> nn <- nnet(TARGET_B ~ ., data=ddn.train, size=1)
```

```
# weights:  13
initial  value 514.759043
iter  10 value 467.665761
iter  20 value 467.663370
iter  30 value 466.024357
iter  40 value 463.035281
```

```
> drawRoc(nn.pred, ddn.test$TARGET_B)
```

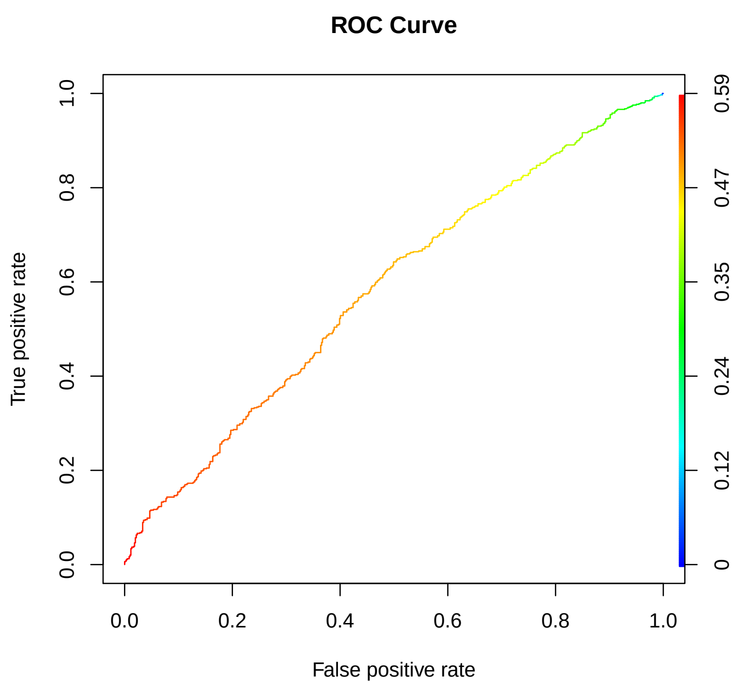


Figure 7: Neural Net ROC curve using Subset Selection

```
iter  50 value 462.850599
iter  60 value 462.834356
iter  70 value 460.655083
iter  80 value 460.009379
iter  90 value 457.699723
iter 100 value 455.028110
final  value 455.028110
stopped after 100 iterations
```

```
> nn.pred <- predict(nn, newdata=ddn.test)
```

Classication Table and Net Profit

```
> nn.ct <- buildClassTab(nn.pred, ddn.test$TARGET_B)
```

```
   Cell Contents
|-------------------------|
```

```
> drawLift(nn.pred, ddn.test$TARGET_B)
```

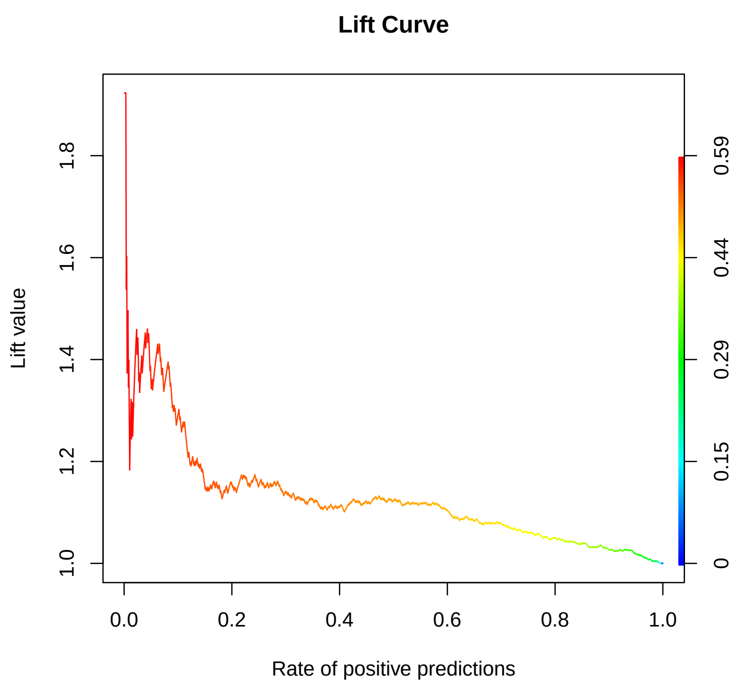


Figure 8: Neural Net Lift curve using Subset Selection

```
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  1248


             | Predicted 
      Actual |         0 |         1 | Row Total | 
-------------|-----------|-----------|-----------|
           0 |       361 |       238 |       599 | 
             |     3.781 |     4.512 |           | 
             |     0.603 |     0.397 |     0.480 | 
             |     0.532 |     0.418 |           | 
             |     0.289 |     0.191 |           | 
-------------|-----------|-----------|-----------|
           1 |       318 |       331 |       649 | 
             |     3.489 |     4.164 |           | 
             |     0.490 |     0.510 |     0.520 | 
             |     0.468 |     0.582 |           | 
             |     0.255 |     0.265 |           | 
-------------|-----------|-----------|-----------|
Column Total |       679 |       569 |      1248 | 
             |     0.544 |     0.456 |           | 
-------------|-----------|-----------|-----------|

> nn.ct

$t
   y
x     0   1
  0 361 238
  1 318 331

$prop.row
   y
x           0         1
  0 0.6026711 0.3973289
  1 0.4899846 0.5100154

$prop.col
   y
```

```
x          0         1
  0 0.5316642 0.4182777
  1 0.4683358 0.5817223

$prop.tbl
   y
x          0         1
  0 0.2892628 0.1907051
  1 0.2548077 0.2652244
```

```
> nn.ct.a <- adjustTabForOversamp(nn.ct, .051)
```

```
   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  12725.49


             | Predicted
      Actual |              [,1] |              [,2] |         Row Total |
-------------|-------------------|-------------------|-------------------|
        [1,] |              7278 |              4798 |             12076 |
             |             0.668 |             0.990 |                   |
             |             0.603 |             0.397 |             0.949 |
             |             0.958 |             0.935 |                   |
             |             0.572 |             0.377 |                   |
-------------|-------------------|-------------------|-------------------|
        [2,] |               318 |               331 |               649 |
             |            12.434 |            18.413 |                   |
             |             0.490 |             0.510 |             0.051 |
             |             0.042 |             0.065 |                   |
             |             0.025 |             0.026 |                   |
-------------|-------------------|-------------------|-------------------|
Column Total |              7596 |              5129 |             12725 |
             |             0.597 |             0.403 |                   |
-------------|-------------------|-------------------|-------------------|
```

```
> nn.ct.a
```

```
$t
         [,1]     [,2]
```

```
[1,] 7278.152 4798.338
[2,]  318.000  331.000

$prop.row
          [,1]      [,2]
[1,] 0.6026711 0.3973289
[2,] 0.4899846 0.5100154

$prop.col
          [,1]       [,2]
[1,] 0.9581367 0.93546926
[2,] 0.0418633 0.06453074

$prop.tbl
           [,1]       [,2]
[1,] 0.57193489 0.37706511
[2,] 0.02498921 0.02601079

> nn.ct.net <- netFromCrossTab(nn.ct.a, prices)
> nn.ct.net

[1] 815.0499
```

Classification under asymmetric response and cost (b)

What is the reasoning behind using weighted sampling to produce training and validation sets with equal numbers of donors and non-donors? Why not use a simple random sample from the original dataset? In this case, is classification accuracy a good performance metric for our purposes of maximizing net profit? If not, how would you determine the best model? Please explain your reasoning.

If simple sampling were used, the non-responders would drown out the responders due to the 94.9% rate of non-responders. Using weighted (over) sampling mitigates this phenomonon.

Classification accuracy is not a good indication of performance as there is a much greater interest in classifiying responders from non-responders.
The best model is determined by comparison. Maximzing fund raising is the goal so the model that produces the Classification Table where this is so wins. ROC and Lift curves are used for quick comparison and to rule out models more quickly then rote eximnation of Classification Tables.

Calculate Net Profit (c)

For each method, calculate the lift of net profit for both the training and validation set based on the actual response rate 5.1%. Again, the expected donation, given that they are donors, is $13.00, and the total cost of each mailing is $0.68.

This was done for each model above, including adjusting for oversampling

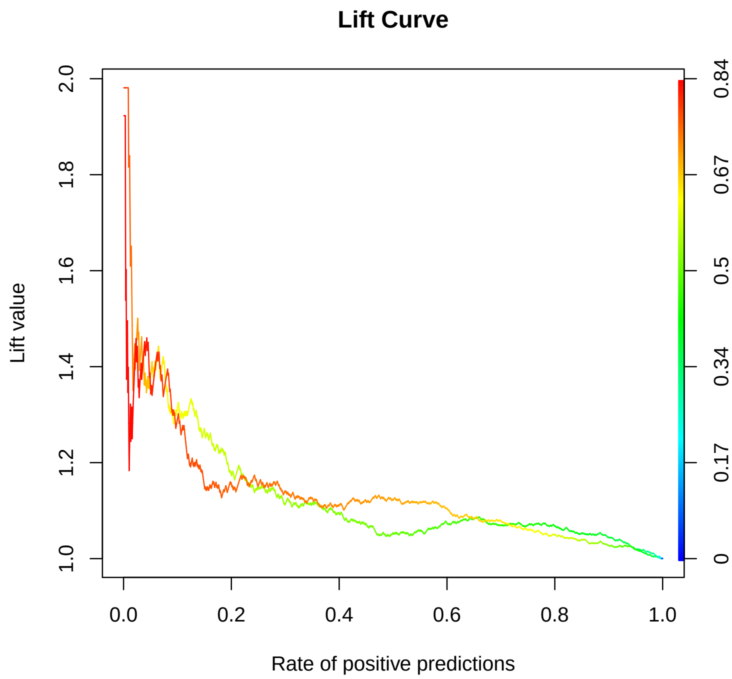
In summary

```
> ct.logit.net

[1] 731.0229

> net.tree.a

[1] 565.0726

> nn.ct.net

[1] 815.0499

>
>
```

Draw Lift Curves (d)

Draw each models net profit lift curve for the validation set onto a single graph. Are there any models that dominate?

```
> drawLift(logit.pred, dd.test$TARGET_B)
> drawLift(nn.pred, ddn.test$TARGET_B, add=TRUE)
> #drawLift(tree.a.pred, dd.test$TARGET_B, add=TRUE)
```



Best Model (e)

From your answer in part 2b, what do you think is the best model?

I choose the Neural Network model as the best in this case. It seems to model the complex relationships between the predcitor variables more accurately, although no model is a clear winner. In this case, it maximizes the fundraising goal.

Future Data

```
> fdd <- getFutureDataClean()
> fdd.nn <- getNnDataPruned(fdd)
> fdd.pred <- predict(nn, newdata=fdd)
> summary(fdd.pred)
```

```
       V1
 Min.   :0.0000
 1st Qu.:0.5902
 Median :0.5902
 Mean   :0.4944
 3rd Qu.:0.5902
```

```
 Max.   :0.5902
 NA's   :1120
```

```
> fdd.pred
```

```
             [,1]
1    5.902334e-01
2    0.000000e+00
3    5.902334e-01
4    5.902334e-01
5    5.902334e-01
6    5.902334e-01
7    0.000000e+00
8    5.902334e-01
9    5.902334e-01
10   0.000000e+00
11   5.902334e-01
12   5.902334e-01
13   5.902334e-01
14   5.902334e-01
15   5.902334e-01
16   0.000000e+00
17   5.902334e-01
18   5.902334e-01
19   0.000000e+00
20   0.000000e+00
21   5.902334e-01
22   0.000000e+00
23   5.902334e-01
24   0.000000e+00
25   5.902334e-01
26   5.902334e-01
27   5.902334e-01
28   5.902334e-01
29   5.902334e-01
30   5.902334e-01
31   5.902334e-01
32   5.902334e-01
33   0.000000e+00
34   0.000000e+00
35   5.902334e-01
36   5.902334e-01
37   5.902334e-01
38   0.000000e+00
39   5.902334e-01
40   5.902334e-01
```

41	5.902334e-01
42	5.902334e-01
43	5.902334e-01
44	5.902334e-01
45	5.902334e-01
46	5.902334e-01
47	5.902334e-01
48	5.902334e-01
49	5.902334e-01
50	5.902334e-01
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52	5.902334e-01
53	5.902334e-01
54	5.902334e-01
55	5.902334e-01
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60	5.902334e-01
61	5.902334e-01
62	5.902334e-01
63	5.902334e-01
64	5.902334e-01
65	5.902334e-01
66	5.902334e-01
67	5.902334e-01
68	0.000000e+00
69	5.902334e-01
70	5.902334e-01
71	5.902334e-01
72	5.902334e-01
73	5.902334e-01
74	5.902334e-01
75	5.902334e-01
76	5.902334e-01
77	5.902334e-01
78	5.902334e-01
79	5.902334e-01
80	5.902334e-01
81	5.902334e-01
82	5.852950e-01
83	0.000000e+00
84	5.902334e-01
85	0.000000e+00
86	5.902334e-01

87	5.902334e-01
88	5.902334e-01
89	5.901071e-01
90	5.902334e-01
91	5.902334e-01
92	5.902334e-01
93	5.902334e-01
94	5.902334e-01
95	0.000000e+00
96	5.902334e-01
97	5.902334e-01
98	5.902334e-01
99	5.902334e-01
100	0.000000e+00
101	0.000000e+00
102	5.902334e-01
103	0.000000e+00
104	0.000000e+00
105	5.902334e-01
106	5.902334e-01
107	5.902334e-01
108	5.902334e-01
109	5.902334e-01
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111	5.902334e-01
112	5.902334e-01
113	5.182083e-01
114	5.902334e-01
115	5.902334e-01
116	0.000000e+00
117	5.902334e-01
118	5.902334e-01
119	5.902334e-01
120	5.902334e-01
121	5.902334e-01
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123	5.902334e-01
124	5.902334e-01
125	5.902334e-01
126	5.902334e-01
127	5.902334e-01
128	0.000000e+00
129	0.000000e+00
130	5.902334e-01
131	5.902334e-01
132	0.000000e+00

133	5.902334e-01
134	5.902334e-01
135	5.902334e-01
136	5.902334e-01
137	5.902334e-01
138	5.902334e-01
139	5.902334e-01
140	5.902334e-01
141	5.902334e-01
142	5.902334e-01
143	5.902334e-01
144	5.902334e-01
145	0.000000e+00
146	0.000000e+00
147	5.902334e-01
148	5.902334e-01
149	5.902334e-01
150	5.902334e-01
151	5.902334e-01
152	5.902334e-01
153	5.902334e-01
154	0.000000e+00
155	5.902334e-01
156	5.902334e-01
157	5.902334e-01
158	0.000000e+00
159	5.902334e-01
160	5.902334e-01
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163	5.902334e-01
164	5.902334e-01
165	5.902334e-01
166	5.902334e-01
167	5.902334e-01
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169	5.902334e-01
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171	5.902334e-01
172	5.902334e-01
173	5.902334e-01
174	5.902334e-01
175	5.902334e-01
176	0.000000e+00
177	5.902334e-01
178	5.902334e-01

179	5.902334e-01
180	0.000000e+00
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182	5.902334e-01
183	5.902334e-01
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185	5.902334e-01
186	5.902334e-01
187	0.000000e+00
188	5.902334e-01
189	5.902334e-01
190	5.902334e-01
191	5.902334e-01
192	5.902334e-01
193	0.000000e+00
194	5.902334e-01
195	5.900551e-01
196	5.902334e-01
197	5.902334e-01
198	5.902334e-01
199	5.902334e-01
200	0.000000e+00
201	5.902334e-01
202	5.902334e-01
203	5.902334e-01
204	0.000000e+00
205	5.902334e-01
206	5.902334e-01
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209	5.902334e-01
210	5.902334e-01
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213	5.902334e-01
214	5.902334e-01
215	5.902334e-01
216	5.902334e-01
217	5.902334e-01
218	0.000000e+00
219	5.902334e-01
220	5.902334e-01
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222	5.902334e-01
223	5.902334e-01
224	5.902334e-01

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226	5.902334e-01
227	5.902334e-01
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229	5.902334e-01
230	0.000000e+00
231	5.902334e-01
232	5.902334e-01
233	0.000000e+00
234	0.000000e+00
235	5.902334e-01
236	5.902334e-01
237	5.902334e-01
238	0.000000e+00
239	5.902334e-01
240	5.898997e-01
241	5.902334e-01
242	5.902334e-01
243	0.000000e+00
244	0.000000e+00
245	5.902334e-01
246	5.902334e-01
247	5.902334e-01
248	5.902334e-01
249	5.902334e-01
250	5.902334e-01
251	0.000000e+00
252	5.902334e-01
253	5.902334e-01
254	5.902334e-01
255	0.000000e+00
256	5.902334e-01
257	5.902334e-01
258	5.902334e-01
259	5.902334e-01
260	0.000000e+00
261	0.000000e+00
262	5.902334e-01
263	0.000000e+00
264	5.902334e-01
265	5.902334e-01
266	5.902334e-01
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268	5.902334e-01
269	0.000000e+00
270	5.491238e-01

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273	5.902334e-01
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275	5.902334e-01
276	5.902334e-01
277	0.000000e+00
278	5.902334e-01
279	5.902334e-01
280	5.902334e-01
281	0.000000e+00
282	5.902334e-01
283	5.902334e-01
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286	5.902334e-01
287	5.902334e-01
288	5.902113e-01
289	5.902334e-01
290	0.000000e+00
291	5.902334e-01
292	5.902334e-01
293	5.902334e-01
294	5.902334e-01
295	5.902334e-01
296	0.000000e+00
297	5.902334e-01
298	5.902334e-01
299	5.902334e-01
300	0.000000e+00
301	5.902334e-01
302	5.902334e-01
303	5.902334e-01
304	5.902334e-01
305	5.902334e-01
306	5.902334e-01
307	5.902334e-01
308	0.000000e+00
309	5.902334e-01
310	5.902334e-01
311	0.000000e+00
312	0.000000e+00
313	0.000000e+00
314	5.902334e-01
315	5.902334e-01
316	0.000000e+00

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327	5.902334e-01
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334	0.000000e+00
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343	5.902334e-01
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346	5.902334e-01
347	0.000000e+00
348	0.000000e+00
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350	5.902334e-01
351	5.902334e-01
352	5.902334e-01
353	5.902334e-01
354	5.902334e-01
355	5.902334e-01
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358	0.000000e+00
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362	0.000000e+00

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368	5.902334e-01
369	5.902334e-01
370	0.000000e+00
371	5.902334e-01
372	0.000000e+00
373	0.000000e+00
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375	5.902334e-01
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389	0.000000e+00
390	0.000000e+00
391	5.902334e-01
392	0.000000e+00
393	0.000000e+00
394	5.902334e-01
395	5.902334e-01
396	0.000000e+00
397	5.902334e-01
398	5.902334e-01
399	0.000000e+00
400	5.902334e-01
401	0.000000e+00
402	0.000000e+00
403	0.000000e+00
404	5.902334e-01
405	5.902334e-01
406	5.902334e-01
407	5.902334e-01
408	5.902334e-01

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410	5.902334e-01
411	5.902334e-01
412	5.902334e-01
413	0.000000e+00
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415	5.902334e-01
416	5.902334e-01
417	5.902334e-01
418	0.000000e+00
419	5.902334e-01
420	0.000000e+00
421	0.000000e+00
422	0.000000e+00
423	0.000000e+00
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430	5.902334e-01
431	5.902334e-01
432	2.284777e-03
433	5.902334e-01
434	5.902334e-01
435	5.902334e-01
436	0.000000e+00
437	0.000000e+00
438	5.902334e-01
439	5.902334e-01
440	5.902334e-01
441	5.902334e-01
442	0.000000e+00
443	5.902334e-01
444	5.902334e-01
445	5.902334e-01
446	0.000000e+00
447	5.902334e-01
448	5.902334e-01
449	5.902334e-01
450	0.000000e+00
451	5.902334e-01
452	5.902334e-01
453	5.902334e-01
454	5.902034e-01

455	5.902334e-01
456	5.902334e-01
457	2.611605e-01
458	5.902334e-01
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461	5.902334e-01
462	5.902334e-01
463	5.902334e-01
464	5.902334e-01
465	5.902334e-01
466	5.902334e-01
467	5.902334e-01
468	5.902334e-01
469	0.000000e+00
470	0.000000e+00
471	5.902334e-01
472	5.902334e-01
473	5.902334e-01
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475	5.902334e-01
476	5.902334e-01
477	5.902334e-01
478	5.902334e-01
479	0.000000e+00
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484	5.902334e-01
485	5.902334e-01
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488	5.902334e-01
489	5.902334e-01
490	0.000000e+00
491	0.000000e+00
492	5.902334e-01
493	5.902334e-01
494	5.902334e-01
495	5.902334e-01
496	0.000000e+00
497	5.902334e-01
498	5.902334e-01
499	5.902334e-01
500	5.902334e-01

501	5.902334e-01
502	5.902334e-01
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504	5.902334e-01
505	5.902334e-01
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507	5.577281e-01
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511	5.902334e-01
512	5.902334e-01
513	0.000000e+00
514	5.902334e-01
515	5.902334e-01
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517	0.000000e+00
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524	5.902334e-01
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527	2.739410e-01
528	0.000000e+00
529	5.902334e-01
530	5.902334e-01
531	0.000000e+00
532	0.000000e+00
533	5.902334e-01
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536	5.902334e-01
537	5.902334e-01
538	5.901892e-01
539	0.000000e+00
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541	5.902334e-01
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543	5.902334e-01
544	5.902334e-01
545	5.902334e-01
546	5.902334e-01

547	5.902012e-01
548	0.000000e+00
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561	5.902223e-01
562	5.902334e-01
563	0.000000e+00
564	0.000000e+00
565	5.902334e-01
566	5.902334e-01
567	5.902334e-01
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569	0.000000e+00
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571	5.902334e-01
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576	5.902334e-01
577	5.902334e-01
578	5.902334e-01
579	5.902334e-01
580	5.902334e-01
581	5.902334e-01
582	5.890666e-01
583	5.902334e-01
584	0.000000e+00
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591	5.902334e-01
592	5.902334e-01

593	5.902334e-01
594	5.902334e-01
595	5.902334e-01
596	5.902334e-01
597	0.000000e+00
598	0.000000e+00
599	5.902334e-01
600	0.000000e+00
601	5.902334e-01
602	5.902334e-01
603	5.902334e-01
604	5.869158e-01
605	5.902334e-01
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607	5.902334e-01
608	5.902334e-01
609	5.902334e-01
610	5.902334e-01
611	5.902334e-01
612	0.000000e+00
613	5.902334e-01
614	5.902334e-01
615	5.902334e-01
616	5.902334e-01
617	5.902334e-01
618	5.902334e-01
619	5.902334e-01
620	5.902334e-01
621	5.902334e-01
622	5.902334e-01
623	5.269861e-01
624	5.902334e-01
625	5.902334e-01
626	5.902334e-01
627	5.902334e-01
628	5.902334e-01
629	5.902334e-01
630	5.902334e-01
631	5.902334e-01
632	5.902334e-01
633	5.902334e-01
634	5.902334e-01
635	5.902334e-01
636	5.902334e-01
637	5.902334e-01
638	5.902334e-01

639	5.902334e-01
640	5.902334e-01
641	5.902334e-01
642	5.902334e-01
643	5.902334e-01
644	5.902334e-01
645	0.000000e+00
646	5.902334e-01
647	5.902334e-01
648	5.902334e-01
649	5.902334e-01
650	5.902334e-01
651	5.902334e-01
652	5.902334e-01
653	0.000000e+00
654	0.000000e+00
655	0.000000e+00
656	0.000000e+00
657	5.902334e-01
658	5.902334e-01
659	5.902334e-01
660	5.902334e-01
661	0.000000e+00
662	5.902334e-01
663	5.902334e-01
664	5.902334e-01
665	0.000000e+00
666	5.902334e-01
667	0.000000e+00
668	5.902334e-01
669	5.902334e-01
670	0.000000e+00
671	5.902334e-01
672	5.902334e-01
673	5.902334e-01
674	5.902334e-01
675	5.902334e-01
676	5.902334e-01
677	5.902334e-01
678	0.000000e+00
679	0.000000e+00
680	5.902334e-01
681	5.902334e-01
682	5.902334e-01
683	5.902334e-01
684	5.902334e-01

685	5.902334e-01
686	5.902334e-01
687	0.000000e+00
688	5.902334e-01
689	5.902334e-01
690	5.902334e-01
691	5.902334e-01
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