DSB

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```r
summary(cars)
```

```
##      speed           dist
##  Min.   : 4.0   Min.   :  2.00
##  1st Qu.:12.0   1st Qu.: 26.00
##  Median :15.0   Median : 36.00
##  Mean   :15.4   Mean   : 42.98
##  3rd Qu.:19.0   3rd Qu.: 56.00
##  Max.   :25.0   Max.   :120.00
```

Including Plots

You can also embed plots, for example:
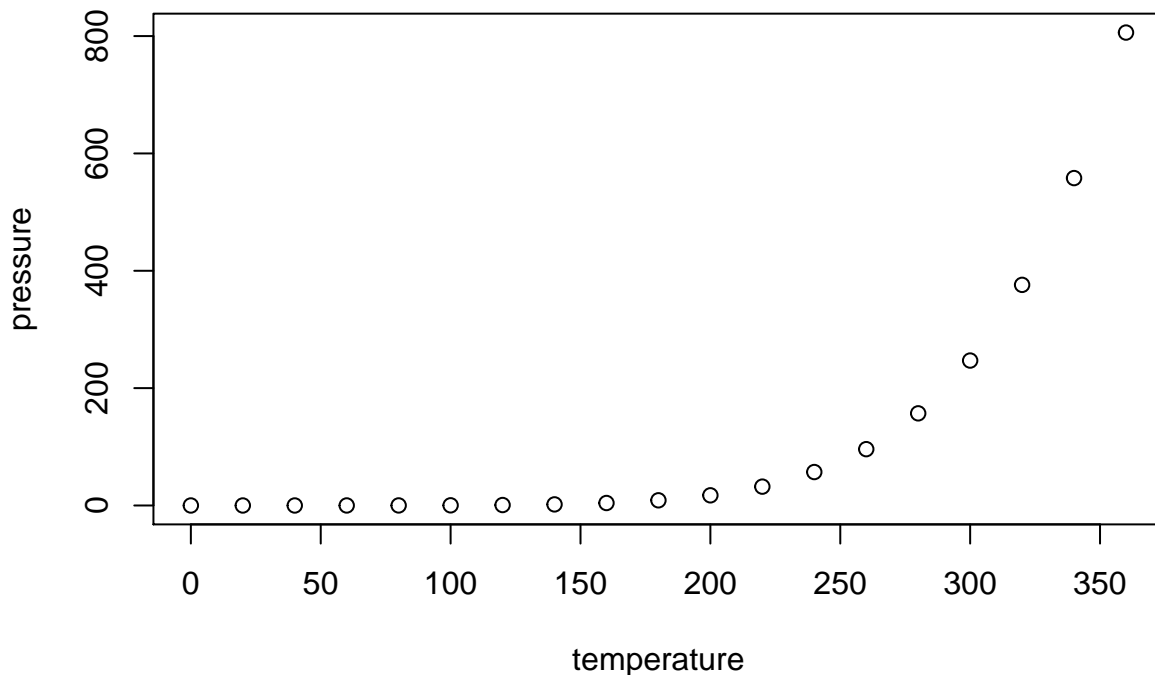
Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.

```r
################################ DSB Final Project Team 18 ############################3

library(ggplot2)
```

```r
source("DataAnalyticsFunctions.R")
##Load dataset in h and clean the dataset
h <- read.csv("UCI_Credit_Card.csv")
h <- h[,-1]

str(h)
```

```
## 'data.frame':    30000 obs. of  24 variables:
##  $ LIMIT_BAL                : num  20000 120000 90000 50000 50000 50000 500000 100000 140000 20000
##  $ SEX                      : int  2 2 2 2 1 1 1 2 2 1 ...
##  $ EDUCATION                : int  2 2 2 2 2 1 1 2 3 3 ...
##  $ MARRIAGE                 : int  1 2 2 1 1 2 2 2 1 2 ...
##  $ AGE                      : int  24 26 34 37 57 37 29 23 28 35 ...
##  $ PAY_0                    : int  2 -1 0 0 -1 0 0 0 0 -2 ...
##  $ PAY_2                    : int  2 2 0 0 0 0 0 -1 0 -2 ...
##  $ PAY_3                    : int  -1 0 0 0 -1 0 0 -1 2 -2 ...
##  $ PAY_4                    : int  -1 0 0 0 0 0 0 0 0 -2 ...
##  $ PAY_5                    : int  -2 0 0 0 0 0 0 0 0 -1 ...
##  $ PAY_6                    : int  -2 2 0 0 0 0 0 -1 0 -1 ...
##  $ BILL_AMT1                : num  3913 2682 29239 46990 8617 ...
##  $ BILL_AMT2                : num  3102 1725 14027 48233 5670 ...
##  $ BILL_AMT3                : num  689 2682 13559 49291 35835 ...
##  $ BILL_AMT4                : num  0 3272 14331 28314 20940 ...
##  $ BILL_AMT5                : num  0 3455 14948 28959 19146 ...
##  $ BILL_AMT6                : num  0 3261 15549 29547 19131 ...
##  $ PAY_AMT1                 : num  0 0 1518 2000 2000 ...
##  $ PAY_AMT2                 : num  689 1000 1500 2019 36681 ...
##  $ PAY_AMT3                 : num  0 1000 1000 1200 10000 657 38000 0 432 0 ...
##  $ PAY_AMT4                 : num  0 1000 1000 1100 9000 ...
##  $ PAY_AMT5                 : num  0 0 1000 1069 689 ...
##  $ PAY_AMT6                 : num  0 2000 5000 1000 679 ...
##  $ default.payment.next.month: int  1 1 0 0 0 0 0 0 0 0 ...
```

```r
for(i in c(2:4,6:11,24)){
  h[,i] <- as.factor(h[,i])
}
str(h)
```

```
## 'data.frame':    30000 obs. of  24 variables:
##  $ LIMIT_BAL                : num  20000 120000 90000 50000 50000 50000 500000 100000 140000 20000
##  $ SEX                      : Factor w/ 2 levels "1","2": 2 2 2 2 1 1 1 2 2 1 ...
##  $ EDUCATION                : Factor w/ 7 levels "0","1","2","3",..: 3 3 3 3 3 2 2 3 4 4 ...
##  $ MARRIAGE                 : Factor w/ 4 levels "0","1","2","3": 2 3 3 2 2 3 3 3 2 3 ...
##  $ AGE                      : int  24 26 34 37 57 37 29 23 28 35 ...
##  $ PAY_0                    : Factor w/ 11 levels "-2","-1","0",..: 5 2 3 3 2 3 3 3 3 1 ...
##  $ PAY_2                    : Factor w/ 11 levels "-2","-1","0",..: 5 5 3 3 3 3 3 2 3 1 ...
##  $ PAY_3                    : Factor w/ 11 levels "-2","-1","0",..: 2 3 3 3 2 3 3 2 5 1 ...
##  $ PAY_4                    : Factor w/ 11 levels "-2","-1","0",..: 2 3 3 3 3 3 3 3 3 1 ...
##  $ PAY_5                    : Factor w/ 10 levels "-2","-1","0",..: 1 3 3 3 3 3 3 3 3 2 ...
##  $ PAY_6                    : Factor w/ 10 levels "-2","-1","0",..: 1 4 3 3 3 3 3 2 3 2 ...
##  $ BILL_AMT1                : num  3913 2682 29239 46990 8617 ...
##  $ BILL_AMT2                : num  3102 1725 14027 48233 5670 ...
```

```
##  $ BILL_AMT3                 : num  689 2682 13559 49291 35835 ...
##  $ BILL_AMT4                 : num  0 3272 14331 28314 20940 ...
##  $ BILL_AMT5                 : num  0 3455 14948 28959 19146 ...
##  $ BILL_AMT6                 : num  0 3261 15549 29547 19131 ...
##  $ PAY_AMT1                  : num  0 0 1518 2000 2000 ...
##  $ PAY_AMT2                  : num  689 1000 1500 2019 36681 ...
##  $ PAY_AMT3                  : num  0 1000 1000 1200 10000 657 38000 0 432 0 ...
##  $ PAY_AMT4                  : num  0 1000 1000 1100 9000 ...
##  $ PAY_AMT5                  : num  0 0 1000 1069 689 ...
##  $ PAY_AMT6                  : num  0 2000 5000 1000 679 ...
##  $ default.payment.next.month: Factor w/ 2 levels "0","1": 2 2 1 1 1 1 1 1 1 1 ...
```
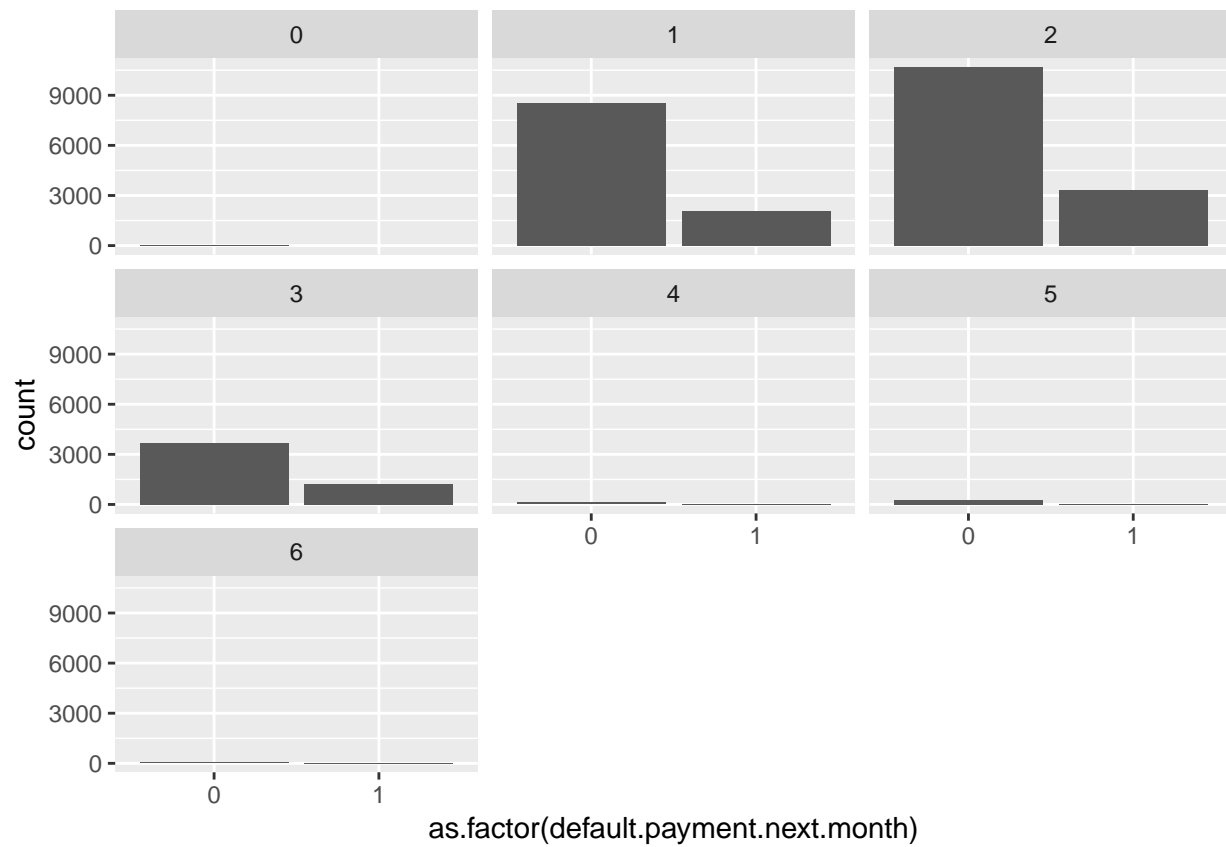
```r
hwop<- h[,-c(7:11)]

##EDA Visualizations
ggplot(h, aes(x=as.factor(default.payment.next.month),y=LIMIT_BAL))+geom_boxplot()
```
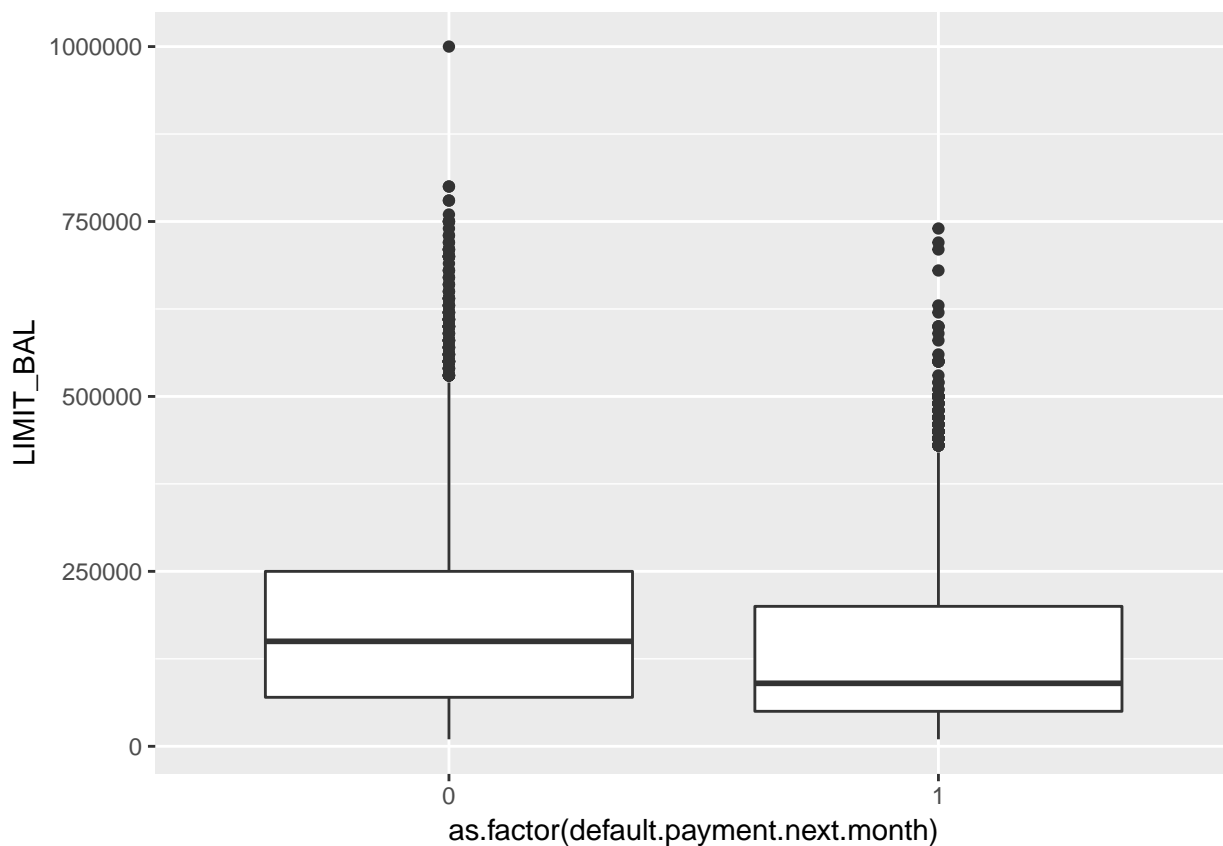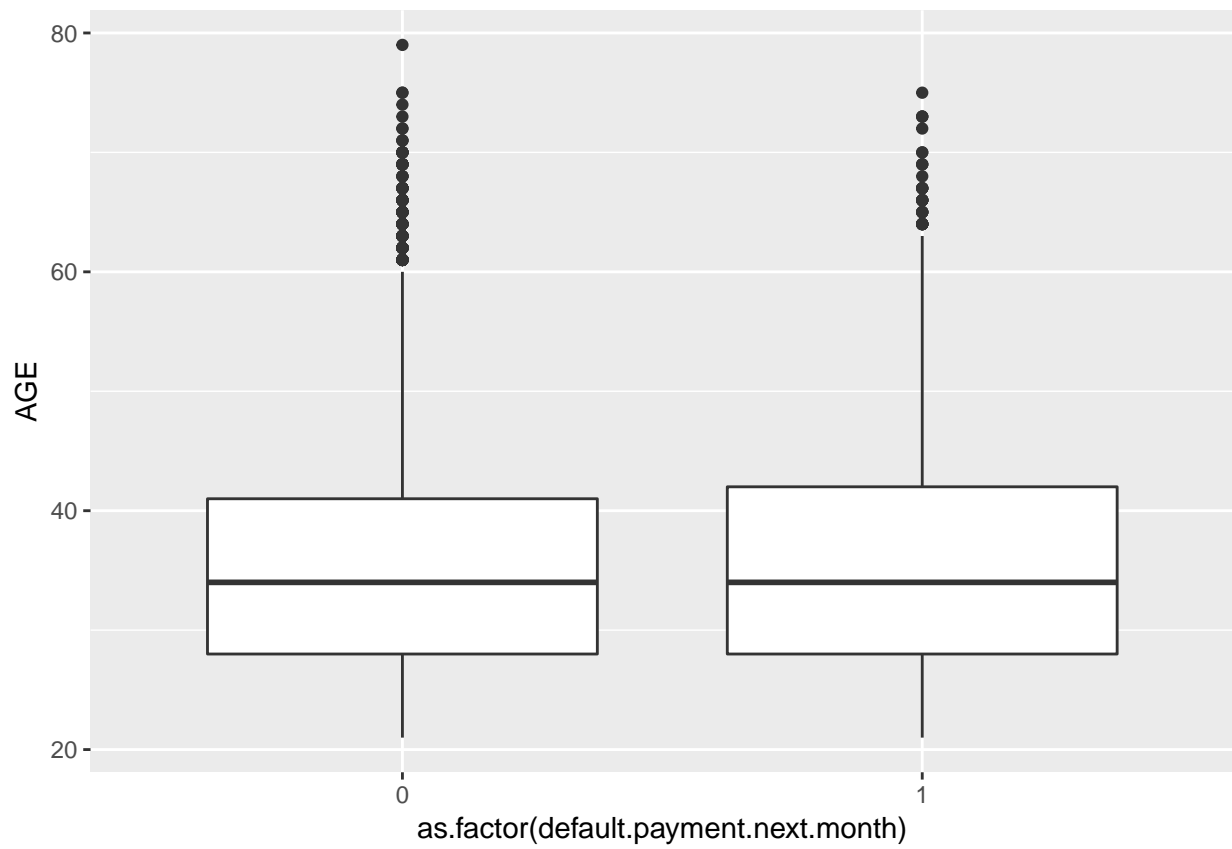


```r
ggplot(h, aes(x=as.factor(default.payment.next.month),fill=drv))+geom_bar(position = "fill")+facet_wrap
```

```
## Error in FUN(X[[i]], ...): object 'drv' not found
```
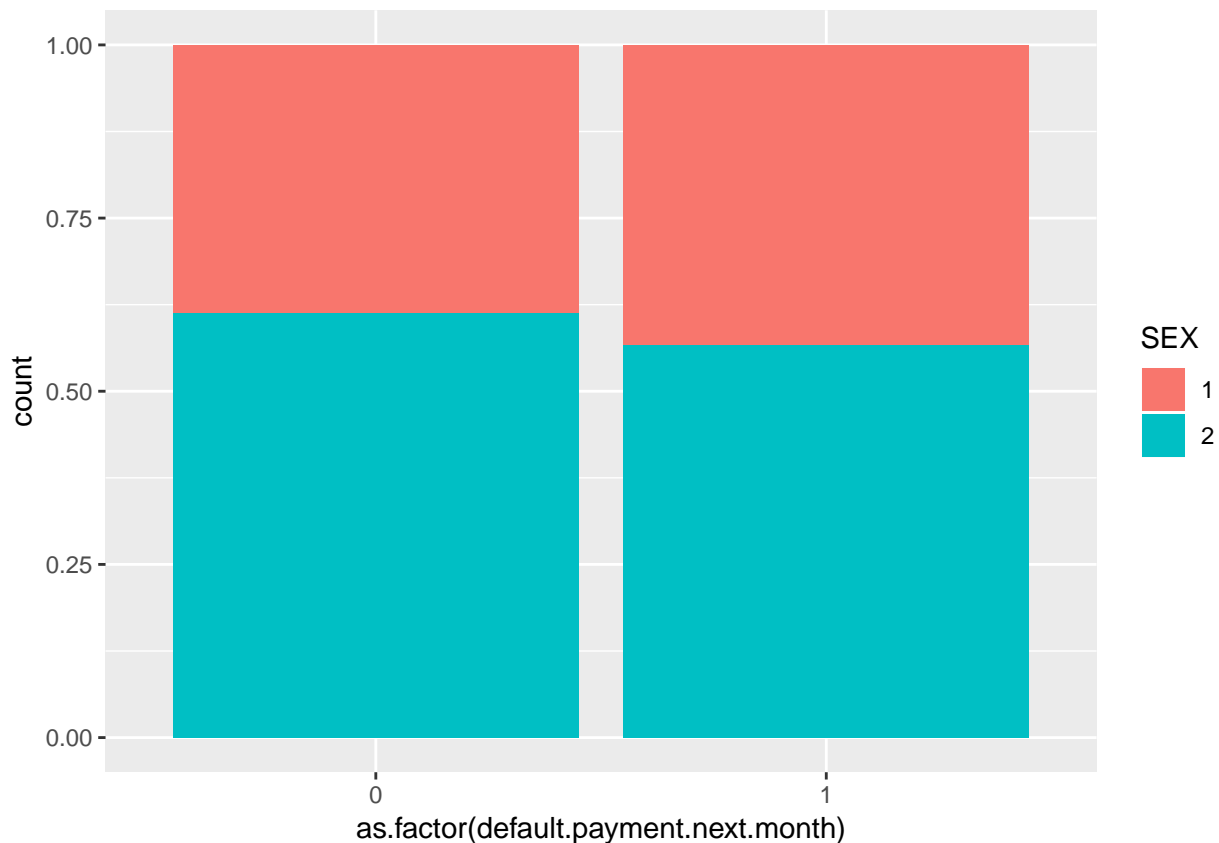
```r
ggplot(h, aes(x=as.factor(default.payment.next.month)))+geom_bar()+facet_wrap(~EDUCATION)
```

```
ggplot(h, aes(x=as.factor(default.payment.next.month),y=AGE))+geom_boxplot()
```

```
ggplot(data=h)+geom_bar(mapping=aes(x=as.factor(default.payment.next.month),fill= SEX), position="fill")
```

```r
#Sex, Education and Default Payment status visualizations
d2 <- ggplot(ccdata2, aes(x=default.payment.next.month),aes(y=stat_count(gender))) +
  geom_bar(aes(fill=factor(ccdata2$educationH))) +
  xlab("Default Payment Status")+ylab("Customer Count") +
  facet_wrap(~genderH)+
  scale_fill_discrete(name="Education")
```

```
## Error in ggplot(ccdata2, aes(x = default.payment.next.month), aes(y = stat_count(gender))): object '
```

```r
#Age, Limit balance and Education visualization
ggplot(data = subset(ccdata2,!is.na(AGE.bucket)), aes(factor(educationH), (LIMIT_BAL/1000), fill=AGE.bu
  geom_boxplot() +
  xlab("Education") +
  ylab("Balance Limit ( x 1000 NT$)") +
  coord_cartesian(ylim = c(0,500)) +
  scale_fill_brewer(palette = "Accent")
```

```
## Error in subset(ccdata2, !is.na(AGE.bucket)): object 'ccdata2' not found
```

```r
##Default Payemnt status among people with different limit balances
ggplot(aes(x = ccdata2$LIMIT_BAL/1000), data = ccdata2) +
  geom_histogram(aes(fill = ccdata2$default.payment.next.month)) +
  xlab("Balance Limit x 1000") +
  ylab("Count") +
  scale_fill_discrete(name="Default Payment Next Month",
```

```
                       breaks=c(0, 1),
                       labels=c("No", "Yes")) + xlim(c(0,750))
```

Error in ggplot(aes(x = ccdata2$LIMIT_BAL/1000), data = ccdata2): object 'ccdata2' not found

```
##Age binning
p<-bin(h$AGE,nbin =6 )
```

Error in bin(h$AGE, nbin = 6): could not find function "bin"

```
p
```

Error in eval(expr, envir, enclos): object 'p' not found

```
##Proportion of defaulters in different age buckets
myage <- table(h$default.payment.next.month,p)
```

Error in table(h$default.payment.next.month, p): object 'p' not found

```
prop.table(myage,2)*100
```

Error in sweep(x, margin, margin.table(x, margin), "/", check.margin = FALSE): object 'myage' not fou

```
##Proportion of defaulters in different education buckets
my <-table(h$default.payment.next.month,h$EDUCATION)
prop.table(my,2)*100
```

```
##
##                 0           1           2           3           4           5
##   0 100.000000  80.765234  76.265146  74.842384  94.308943  93.571429
##   1   0.000000  19.234766  23.734854  25.157616   5.691057   6.428571
##
##                 6
##   0   84.313725
##   1   15.686275
```

```
#Payment Status correlation
pay <- h[,(6:11)]
corh<-cor(pay)
```

Error in cor(pay): 'x' must be numeric

```
corrplot(corh)
```

Error in corrplot(corh): could not find function "corrplot"

```r
#Bill Amount Correlation
bill <- h[,(12:17)]
corb<-cor(bill)
corrplot(corb)
```

```
## Error in corrplot(corb): could not find function "corrplot"
```

```r
##Kmeans Clustering
##Load the same dataset in k and use it for clustering
k <- read.csv("UCI_Credit_Card.csv")
Ssimple <- scale(k[,c(2:6)])
head(Ssimple)
```

```
##         LIMIT_BAL        SEX EDUCATION  MARRIAGE        AGE
## [1,] -1.1367012  0.8101472  0.1858252 -1.057277 -1.2459991
## [2,] -0.3659744  0.8101472  0.1858252  0.858543 -1.0290300
## [3,] -0.5971924  0.8101472  0.1858252  0.858543 -0.1611538
## [4,] -0.9054832  0.8101472  0.1858252 -1.057277  0.1642998
## [5,] -0.9054832 -1.2343024  0.1858252 -1.057277  2.3339904
## [6,] -0.9054832 -1.2343024 -1.0794392  0.858543  0.1642998
```

```r
kfit <- lapply(1:30, function(k) kmeans(Ssimple,k,nstart=10))
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```r
kaic <- sapply(kfit,kIC)
kbic  <- sapply(kfit,kIC,"B")
kHDic  <- sapply(kfit,kIC,"A")
par(mar=c(1,1,1,1))
par(mai=c(1,1,1,1))
plot(kaic, xlab="k (# of clusters)", ylab="IC (Deviance + Penalty)", main=paste("THE ELBOW METHOD"),
     ylim=range(c(kaic,kbic,kHDic)),
     type="l", lwd=2)
```
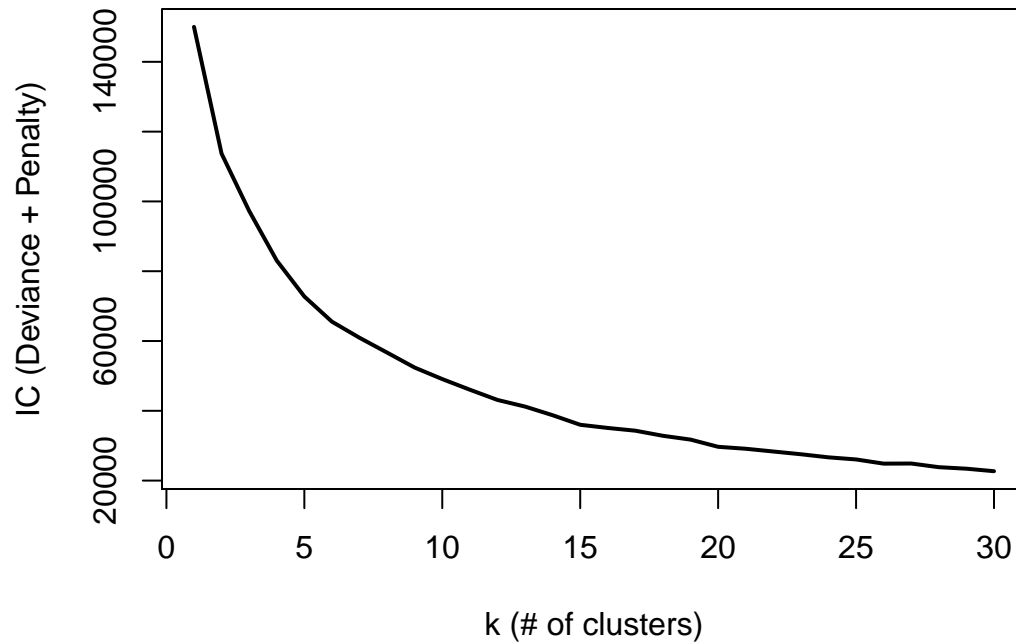
THE ELBOW METHOD

k (# of clusters)

```
#Number of clusters determined by elbow method = 7

##Cluster features and centers
simple_kmeans <- kmeans(Ssimple,7,nstart=5)
colorcluster <- 1+simple_kmeans$cluster
simple_kmeans$centers
```

```
##     LIMIT_BAL        SEX    EDUCATION    MARRIAGE         AGE
## 1   1.4767819  0.2167069 -0.622666586   0.8769949 -0.18197877
## 2  -0.3150709 -1.2343024  0.210006187  -1.0087756  0.69700222
## 3   1.7097714 -0.1181804 -0.510564304  -1.0451655  0.74686458
## 4  -0.4315374  0.8101472 -0.262257430   0.8950293 -0.75337502
## 5  -0.3593916  0.5924210  1.654555900  -0.2989743  1.13110996
## 6  -0.2294465  0.8101472 -0.006766253  -1.0697548  0.03195435
## 7  -0.4894294 -1.2343024 -0.089272583   0.8974625 -0.48358949
```

```
simple_kmeans$size
```

```
## [1] 3011 4029 2689 6616 2817 5374 5464
```

```
simple_kmeans$cluster
```

```
##     [1] 6 4 4 6 2 7 1 4 6 7 5 1 1 7 7 4 7 3 3 4 5 6 4 3 7 7 7 4 5 7 4 7 7 3
##    [35] 3 7 2 4 7 1 1 4 7 6 4 7 4 5 1 7 7 4 3 4 4 3 6 6 4 3 3 2 7 6 6 2 2 4
##    [69] 4 5 7 7 6 1 1 7 7 3 4 1 1 1 7 3 5 7 3 4 6 7 2 1 4 6 4 7 3 7 6 2 7 1
##   [103] 3 4 4 4 6 1 7 3 3 2 2 4 7 7 7 7 3 1 7 3 6 6 7 7 5 2 2 2 4 7 3 2 4 2
##   [137] 7 6 5 7 7 7 7 7 7 7 4 7 6 3 2 7 1 3 4 2 4 4 2 2 7 7 2 6 6 4 1 2 6 4
```

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```
##    [171] 7 1 4 4 1 2 7 7 4 6 7 5 3 6 7 6 1 5 6 4 1 4 4 4 2 4 6 4 3 4 6 7 4 7
##    [205] 3 2 2 6 4 3 7 6 5 7 1 2 6 7 6 1 3 5 1 1 5 4 2 2 7 4 4 7 2 7 6 7 4 4
##    [239] 5 4 4 7 4 4 4 4 5 4 1 2 4 7 4 4 1 2 6 6 5 2 1 7 6 1 4 6 7 5 4 7 7 2
##    [273] 1 4 1 4 3 4 2 6 4 2 4 4 6 6 7 3 4 6 1 4 2 7 7 7 6 6 6 1 7 1 5 4 4 4
##    [307] 3 6 2 4 3 6 7 5 7 7 4 5 5 7 7 1 7 6 1 7 6 6 3 2 6 4 4 3 7 4 1 4 6 4
##    [341] 4 7 4 2 4 4 4 4 4 4 7 2 1 4 2 2 4 1 5 3 1 1 7 2 1 3 5 7 3 6 2 7 4 7
##    [375] 2 2 2 4 7 7 4 6 2 4 7 5 4 5 2 3 3 6 2 4 3 4 7 4 6 4 7 4 7 2 4 2 6 3
##    [409] 1 1 4 6 6 4 3 5 4 4 2 1 7 1 4 2 3 6 5 4 7 4 4 1 4 3 2 6 4 2 6 4 7 7
##    [443] 4 4 7 7 4 6 5 6 3 3 7 4 7 7 7 7 6 2 6 6 1 4 5 2 7 7 3 6 1 1 2 2 6 4
##    [477] 7 6 3 7 6 7 4 2 6 2 6 3 6 6 4 6 7 4 6 2 5 7 3 2 6 6 5 6 5 7 1 4 6 7
##    [511] 2 4 1 7 4 2 2 2 4 6 6 1 1 6 4 4 7 3 1 4 7 7 7 5 7 7 1 2 4 6 4 4 6 4
##    [545] 3 1 6 4 4 7 2 4 2 6 4 3 6 4 7 5 7 1 6 1 1 5 4 1 7 3 4 4 1 5 5 3 1 7
##    [579] 7 2 7 7 7 5 7 4 2 7 4 6 6 7 2 2 5 2 1 4 4 6 3 2 2 4 4 7 6 4 3 6 7 1
##    [613] 2 7 6 7 6 3 7 6 6 4 4 3 4 4 2 2 2 5 5 4 6 6 2 5 5 2 1 7 2 6 4 1 6 7
##    [647] 2 4 6 5 7 4 4 3 7 2 4 4 4 1 6 2 4 7 6 5 6 6 5 6 4 2 4 7 3 7 7 7 1 4
##    [681] 4 4 6 1 3 3 5 4 2 7 7 7 6 7 3 4 6 4 3 1 1 6 4 4 4 7 2 5 7 7 7 6 3 2
##    [715] 1 6 4 6 6 5 4 7 4 3 4 2 1 1 1 7 4 2 7 6 2 5 4 1 4 4 6 4 6 7 6 7 6 6
##    [749] 4 4 6 4 7 1 3 2 4 6 1 4 5 4 6 4 6 1 6 4 2 6 1 1 2 6 4 4 7 7 6 4 7 2
##    [783] 4 6 6 1 1 6 7 4 5 7 1 5 6 6 4 4 4 6 1 7 5 4 7 3 4 5 4 6 4 3 4 6 2 6
##    [817] 2 4 6 7 5 4 2 4 7 4 6 7 5 6 1 6 3 4 4 5 4 5 3 3 4 3 6 4 3 3 6 7 2 5
##    [851] 4 7 2 4 5 4 4 5 7 4 7 3 5 6 7 6 4 7 6 1 4 5 3 2 5 6 7 4 6 6 7 6 1 5
##    [885] 5 4 1 6 4 1 6 1 6 1 6 7 7 4 5 2 1 6 7 2 4 4 7 4 7 1 4 1 5 2 2 2 3 7
##    [919] 7 4 1 4 2 4 4 7 2 4 4 2 4 3 4 7 6 7 4 7 6 6 4 2 3 4 4 1 6 2 1 5 2 6
##    [953] 1 7 6 2 4 6 1 7 1 7 7 7 3 7 6 6 6 3 6 5 4 2 4 7 7 5 4 7 1 2 4 7
##    [987] 6 3 1 2 5 3 4 1 1 7 2 3 4 7 2 6 6 1 4 7 4 6 7 4 1 3 1 7 3 6 4 5 5 6
##   [1021] 7 4 5 6 7 2 7 1 7 5 3 7 4 4 4 7 7 2 4 7 7 5 6 4 4 4 2 4 3 2 7 4 2 7
##   [1055] 2 7 4 6 5 2 6 2 3 3 5 6 7 7 7 4 2 6 1 5 4 5 1 1 5 3 4 2 4 4 4 6 3 6
##   [1089] 5 1 4 7 2 3 7 1 7 2 7 2 5 4 6 4 6 3 6 6 2 4 7 5 6 7 2 7 4 7 5 6 4 7
##   [1123] 7 6 4 3 1 3 4 4 6 4 3 6 7 4 7 2 5 5 7 4 6 6 6 2 4 1 4 2 6 7 4 4 2 6
##   [1157] 4 3 3 7 7 6 6 6 7 4 2 5 4 5 4 2 5 4 6 7 4 4 7 7 2 1 5 4 1 7 2 6 3 4
##   [1191] 4 7 1 2 5 6 6 2 5 3 5 7 1 4 6 6 5 2 6 2 6 4 6 6 1 7 2 3 4 7 4 4 7 6
##   [1225] 7 7 5 3 6 5 4 1 2 6 1 2 7 2 2 6 3 6 6 5 7 7 2 4 5 3 7 4 4 7 3 7 7 4
##   [1259] 7 7 7 3 2 5 7 5 6 4 7 4 5 4 3 4 2 7 3 7 7 1 4 1 5 2 1 3 6 3 5 4 4 5
##   [1293] 6 1 7 1 7 6 4 2 7 4 4 7 7 2 4 6 4 2 2 7 7 1 6 2 3 2 3 3 1 6 3 7 2 2
##   [1327] 2 4 2 6 7 4 6 2 4 4 4 1 4 5 5 6 4 4 2 4 6 1 1 5 7 3 7 6 6 5 7 6 3 1
##   [1361] 4 4 6 4 2 6 5 7 4 5 3 4 3 7 7 5 5 3 2 7 6 2 4 1 6 1 1 6 2 4 2 4 6 4
##   [1395] 4 1 4 3 2 4 6 2 6 1 3 3 4 6 4 1 1 3 2 2 1 4 4 4 7 7 4 4 4 4 7 7 4
##   [1429] 6 4 6 6 7 2 7 7 4 7 2 4 4 6 2 2 7 4 6 4 7 5 6 1 2 7 7 2 4 3 4 7 6 7
##   [1463] 4 3 4 2 4 6 3 4 2 7 3 7 4 7 7 7 4 1 3 4 3 1 4 4 7 2 7 4 5 5 5 7 4 2
##   [1497] 1 6 5 7 6 6 2 2 3 3 4 6 3 6 4 2 7 4 4 6 4 2 1 3 1 7 4 4 6 7 6 7 7 3
##   [1531] 4 3 7 4 2 2 2 4 6 4 4 7 7 6 7 1 6 7 4 1 6 2 6 5 6 7 3 7 3 6 5 6 4 7 5
##   [1565] 6 7 6 4 6 4 2 2 6 7 5 4 4 7 6 6 6 7 5 5 6 5 3 1 1 6 5 4 2 7 1 3 6 4
##   [1599] 7 7 7 6 5 1 4 4 2 6 1 6 4 6 5 6 3 3 7 3 4 4 4 7 4 7 7 2 5 6 6 7 7 6
##   [1633] 1 4 6 7 2 5 4 5 2 4 7 7 5 2 4 2 5 2 3 7 2 3 7 6 4 7 4 4 5 6 4 1 3 2
##   [1667] 6 2 7 7 2 4 7 1 3 7 1 3 3 4 4 4 7 2 4 3 6 7 7 2 1 5 4 5 4 2 2 5 7 1
##   [1701] 5 6 4 1 4 7 7 6 1 6 4 3 2 3 4 6 7 7 6 5 1 7 2 4 1 1 5 6 5 2 6 4 6 7
##   [1735] 6 7 4 1 4 7 2 7 4 7 7 4 4 6 4 4 6 7 6 6 7 2 7 1 6 7 6 2 7 1 4 4 4 4
##   [1769] 7 6 3 5 6 7 4 6 3 2 7 2 3 5 2 4 3 2 6 4 4 7 6 4 1 1 5 7 2 4 6 7 6 2
##   [1803] 6 4 1 2 5 4 7 1 7 2 7 4 4 7 2 6 6 4 2 4 5 4 6 1 6 2 3 7 2 5 1 7 6 4
##   [1837] 4 6 4 5 6 1 4 7 7 5 7 7 7 7 3 1 4 4 5 5 1 7 7 2 4 7 3 4 1 4 1 2 5 6
##   [1871] 6 4 4 4 2 6 2 2 6 5 5 6 7 5 4 7 7 6 6 5 4 2 4 6 7 2 7 3 7 6 4 4 3 1
##   [1905] 3 3 3 1 7 4 3 4 2 1 1 4 4 4 4 2 6 1 7 1 7 1 4 4 7 3 2 4 1 2 1 1 4 1
##   [1939] 3 2 4 2 2 7 7 4 1 3 7 2 4 2 3 7 6 7 6 4 6 5 4 5 6 7 6 4 2 5 7 1 2 2
##   [1973] 2 7 7 4 7 4 5 3 6 5 2 7 4 5 7 4 7 7 7 3 3 3 5 4 4 5 6 2 7 2 4 4 1 7
```

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```
## [2007] 2 3 3 6 4 2 4 5 6 3 4 2 5 6 6 4 2 6 7 6 7 1 7 6 3 1 3 6 4 6 1 6 4 5
## [2041] 4 2 3 4 7 7 5 4 4 6 2 7 4 2 2 2 4 5 2 2 6 1 6 2 2 7 7 7 2 6 4 2 7 2
## [2075] 7 4 2 2 7 2 4 6 6 2 5 7 2 6 5 6 3 7 7 5 7 6 5 6 1 4 6 4 5 7 3 7 7 6
## [2109] 6 4 7 3 6 7 6 6 7 7 5 1 4 6 7 4 1 4 4 6 5 1 2 7 7 4 2 7 7 6 4 3 4 2
## [2143] 5 2 6 2 5 7 2 4 7 7 2 7 4 4 1 1 6 2 5 3 3 7 1 3 3 3 2 4 4 2 2 1 1 3
## [2177] 1 1 6 5 1 4 1 6 2 2 5 2 7 4 2 4 3 2 2 7 7 3 5 2 4 6 2 7 2 6 4 4 2 6
## [2211] 1 1 7 7 7 6 1 7 2 3 6 5 3 7 3 7 3 6 4 6 6 1 4 5 7 6 7 6 5 1 3 4 4 4
## [2245] 2 6 7 2 4 3 4 6 6 5 6 4 4 4 4 4 7 7 4 1 4 3 6 2 4 4 6 1 5 7 5 2 5
## [2279] 5 6 4 3 5 4 5 2 7 4 7 7 7 2 5 3 4 6 5 3 7 4 6 6 6 7 2 6 6 4 7 2 6 7
## [2313] 2 4 4 5 6 2 1 5 2 6 4 7 4 5 4 4 4 6 7 4 7 6 4 6 6 5 4 2 7 4 2 5 3 7
## [2347] 1 4 7 7 3 3 2 4 4 7 3 3 7 7 6 4 7 7 6 5 3 4 3 6 7 4 5 1 4 2 2 7 7 3
## [2381] 4 3 3 2 2 1 4 6 3 4 7 1 2 5 4 6 2 6 7 7 2 3 4 1 7 5 5 1 4 6 4 1 7 7
## [2415] 2 4 4 4 7 3 4 6 5 6 7 7 5 7 2 4 2 7 6 4 4 6 6 7 4 5 4 3 2 5 2 7 4 4
## [2449] 6 3 5 2 4 4 1 3 3 6 4 6 1 4 7 7 5 6 7 4 7 4 4 7 5 5 1 4 2 7 7 6 7 2
## [2483] 4 6 4 1 2 2 6 7 7 1 3 6 2 3 1 5 2 1 3 4 4 7 7 2 5 7 7 2 4 3 3 2 5 4
## [2517] 6 4 6 4 6 7 7 4 7 4 3 3 4 7 7 2 4 4 7 2 6 2 3 2 2 6 7 6 7 7 2 7 7 7
## [2551] 4 7 6 4 6 6 7 4 7 4 1 7 2 6 4 1 1 2 2 5 4 4 6 4 6 2 5 2 7 4 1 4 5 3
## [2585] 4 7 7 4 4 6 1 4 3 5 6 7 4 4 5 3 5 2 7 1 7 2 7 3 6 3 1 7 4 2 4 3 3 6
## [2619] 4 6 4 1 4 7 3 5 7 4 3 6 7 5 1 2 6 6 7 1 2 6 5 5 7 3 6 7 1 7 2 4 2 1
## [2653] 4 1 4 6 7 6 6 2 7 3 1 2 4 4 4 6 7 5 1 3 4 1 5 2 2 4 4 7 5 4 7 1 2 2
## [2687] 1 3 1 4 2 6 3 6 7 3 5 4 5 2 7 5 4 4 4 4 2 4 7 4 1 3 6 4 7 6 4 1 4 2
## [2721] 4 4 7 5 5 4 6 7 2 1 7 7 4 4 1 6 6 6 3 2 6 7 6 4 2 1 6 6 2 2 6 1 5 4
## [2755] 7 4 2 7 4 4 6 4 2 6 7 2 6 4 3 6 4 2 4 2 3 5 6 3 6 4 6 4 1 3 4 6 2 4
## [2789] 4 7 6 7 5 1 6 7 6 2 6 7 7 7 2 7 6 6 7 4 3 3 6 4 4 7 4 5 2 4 4 6 2 5
## [2823] 3 5 6 6 3 5 4 6 2 6 7 5 6 2 1 4 4 4 4 1 6 4 4 4 1 4 4 7 5 6 6 3 4 3
## [2857] 7 6 3 4 4 1 7 2 6 2 4 7 4 3 4 6 1 1 7 4 4 4 4 4 7 7 4 3 7 5 2 3 6 5
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## [29683] 2 7 1 2 1 7 2 7 3 7 7 1 2 2 3 2 3 7 2 2 7 7 7 2 3 2 2 7 3 7 7 2 7 7
## [29717] 2 7 2 2 7 2 2 2 2 2 2 7 2 3 2 2 2 2 3 2 3 2 7 3 1 2 7 7 7 7 7 7 7 7
## [29751] 7 2 7 7 2 2 7 7 7 2 3 3 2 2 7 5 7 2 7 2 7 2 2 7 7 7 1 7 1 2 7 7 2 2
## [29785] 2 7 2 7 2 7 2 2 3 7 3 2 7 2 2 7 7 7 7 7 2 2 7 2 2 2 7 5 2 7 7 7 7 7
## [29819] 7 7 1 3 2 2 2 2 2 2 7 7 1 7 7 7 7 7 5 1 2 5 3 3 3 2 3 2 1 5 7 7 2 7
## [29853] 3 7 3 7 2 2 2 2 2 1 3 2 7 2 2 7 1 1 7 7 1 2 7 2 3 2 1 2 7 2 3 5 3 2 2
## [29887] 3 2 2 3 2 5 2 3 2 2 2 2 7 7 7 7 7 3 7 2 7 7 7 1 7 2 1 7 1 7 1 7 7 2
## [29921] 5 1 2 1 2 7 2 7 7 2 2 7 2 2 3 2 7 3 7 2 2 7 2 1 7 2 7 2 3 3 2 7 7 7
## [29955] 7 1 7 1 7 1 2 7 7 1 1 2 5 2 7 2 3 2 2 2 2 2 7 1 2 2 7 2 2 2 7 7 1 7
## [29989] 2 7 2 2 2 7 7 2 7 7 2 2
```
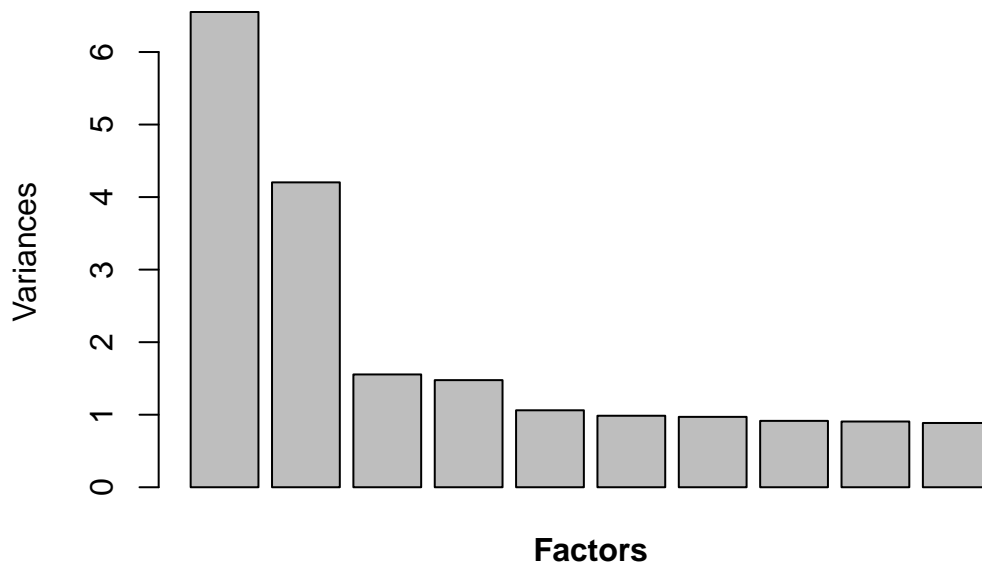
```r
library(cluster)
clusplot(k,simple_kmeans$cluster,lines=0,color=TRUE,plotchar = FALSE,span=TRUE,main=paste("Clusters"),x
```

Clusters
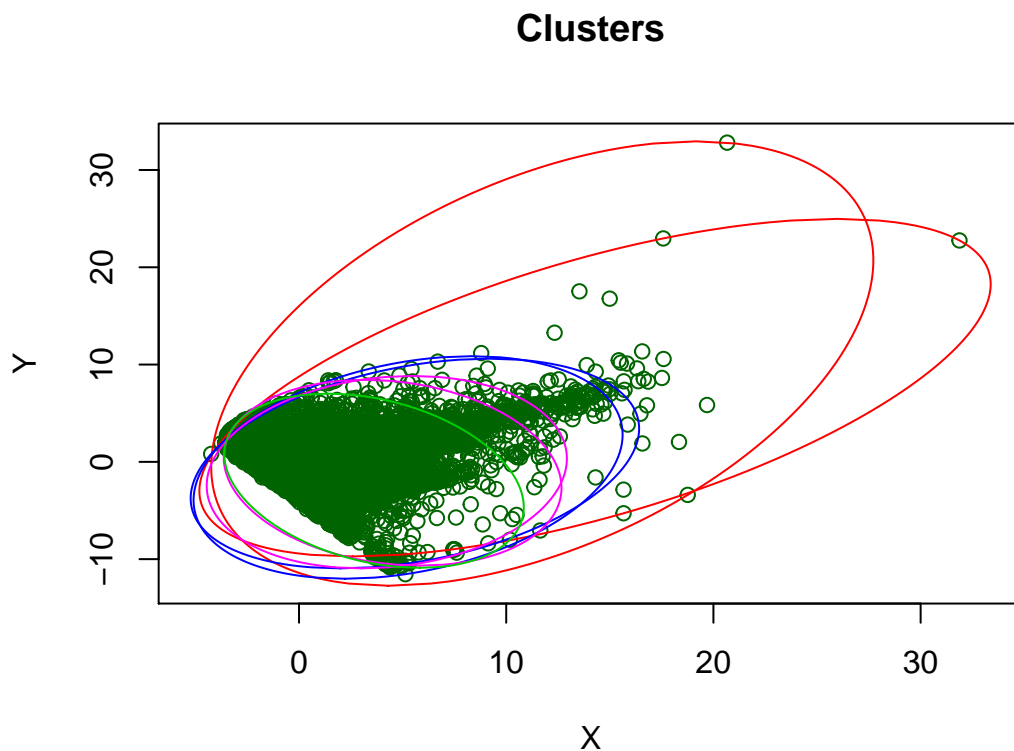
These two components explain 43.02 % of the point variability.

```r
##PCA - Latent features
pca.h <- prcomp(k, scale=TRUE)
plot(pca.h,main="PCA: Variance Explained by Factors")
mtext(side=1, "Factors",  line=1, font=2)
```

PCA: Variance Explained by Factors


```
loadings <- pca.h$rotation[,1:4]
v<-loadings[order(abs(loadings[,1]), decreasing=TRUE)[1:27],1]
loadingfit <- lapply(1:27, function(k) ( t(v[1:k])%*%v[1:k] - 3/4 )^2)
v[1:which.min(loadingfit)]
```

```
## BILL_AMT4 BILL_AMT5 BILL_AMT3 BILL_AMT2 BILL_AMT6 BILL_AMT1     PAY_5
## 0.3522465 0.3501291 0.3481048 0.3441620 0.3429270 0.3327495 0.2135893
```

```
v2<-loadings[order(abs(loadings[,2]), decreasing=TRUE)[1:27],2]
loadingfit <- lapply(1:27, function(k) ( t(v2[1:k])%*%v2[1:k] - 3/4 )^2)
v2[1:which.min(loadingfit)]
```

```
##                   PAY_3                    PAY_4
##              -0.3349820                -0.3343807
##                   PAY_2                    PAY_5
##              -0.3279053                -0.3213180
##               LIMIT_BAL                    PAY_0
##               0.3115198                -0.2966875
##                   PAY_6 default.payment.next.month
##              -0.2959196                -0.1763267
##                 PAY_AMT3
##               0.1500399
```

```
h$default.payment.next.month
```

```
##     [1] 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 1 0 0 1 0 0 0 0 1 0 0
##    [35] 0 0 0 1 0 0 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 1 1 0
##    [69] 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0
##   [103] 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 0 1 0 0 0 1 1 0 0 0 0 0 0 0
##   [137] 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
```

```
##    [171] 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0
##    [205] 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 1 0 1 0 0 0 0
##    [239] 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0
##    [273] 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0
##    [307] 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 1 0 0 1 1 0 0 1 1 0 0 0 0 0 0 1 0
##    [341] 0 0 0 0 0 0 1 0 1 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 0
##    [375] 0 0 0 0 1 0 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0
##    [409] 0 0 1 0 0 1 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0
##    [443] 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0
##    [477] 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0
##    [511] 0 1 0 1 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0
##    [545] 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0
##    [579] 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1
##    [613] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##    [647] 1 0 1 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 1 1 0 1 1 0 0 0
##    [681] 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0
##    [715] 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1
##    [749] 1 1 0 0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
##    [783] 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0
##    [817] 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 1 0
##    [851] 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
##    [885] 1 0 0 0 0 0 0 0 0 1 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1
##    [919] 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0
##    [953] 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 0 1 0 0 1
##    [987] 0 0 0 0 0 1 0 1 1 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 1 0 0
##   [1021] 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 0 1 0 0 0 1 0 0 1 0 1 1 0 0 0 0 0
##   [1055] 0 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0
##   [1089] 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 1 1
##   [1123] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 0 0
##   [1157] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0
##   [1191] 0 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1
##   [1225] 0 1 0 0 1 0 1 0 0 0 0 1 1 0 1 0 0 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0
##   [1259] 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
##   [1293] 0 1 0 0 0 0 1 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0
##   [1327] 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0
##   [1361] 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
##   [1395] 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##   [1429] 1 0 0 1 1 0 0 1 1 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 0 0 0 1 1 0 1 0
##   [1463] 0 0 0 0 1 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0
##   [1497] 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0
##   [1531] 0 0 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0 1 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0
##   [1565] 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##   [1599] 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0 1 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0
##   [1633] 0 0 0 0 0 1 0 0 0 1 0 1 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1 0 0
##   [1667] 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0
##   [1701] 0 0 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 1 1 0 0
##   [1735] 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0
##   [1769] 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0
##   [1803] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1
##   [1837] 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1
##   [1871] 0 0 0 0 1 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0
##   [1905] 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 1 0 1 1
##   [1939] 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 1
##   [1973] 0 0 1 0 0 0 0 1 1 1 0 1 0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0
```

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```
## [2007] 0 0 1 0 0 0 1 0 0 1 1 1 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0
## [2041] 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0
## [2075] 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0
## [2109] 0 0 0 1 0 1 1 0 1 1 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 0 0
## [2143] 1 1 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
## [2177] 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0
## [2211] 0 0 0 0 0 0 1 1 1 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1
## [2245] 0 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0
## [2279] 1 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 1 0 0 0 1 0 1 0 0 0 0 0 0 0
## [2313] 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0
## [2347] 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 1 0 1 1 0
## [2381] 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0
## [2415] 1 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 0 1 0 1 1 1 1 0 0 0 1 0 0 0 1 0 1
## [2449] 0 1 1 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 1 1 0 0 0 0 0 0 0 1 0
## [2483] 1 1 0 0 0 1 1 0 0 1 0 0 1 0 0 0 1 0 1 0 0 1 0 0 1 1 0 1 1 1 1 0 0 0
## [2517] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 1 0 0 1 1 0 0 0 0
## [2551] 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0
## [2585] 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 1 0 0 0 0 0 0 1 1
## [2619] 0 1 0 0 0 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 1 1 0 0 1 0 1 1 0 0 1 1
## [2653] 0 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0
## [2687] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
## [2721] 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 1 0 0 1 1
## [2755] 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 1 0 0 0 1 0 0 1
## [2789] 0 1 1 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1
## [2823] 0 1 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0
## [2857] 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [2891] 0 0 0 0 0 1 0 0 1 0 0 0 1 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1
## [2925] 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0
## [2959] 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1
## [2993] 0 1 0 1 1 0 1 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 1 1 0 0 1 1 0
## [3027] 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
## [3061] 1 0 0 0 0 1 0 1 0 0 0 1 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [3095] 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [3129] 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 0
## [3163] 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0
## [3197] 0 0 0 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0
## [3231] 1 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0
## [3265] 1 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 1 0 0
## [3299] 1 1 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0
## [3333] 1 0 0 1 1 0 0 1 0 0 0 1 1 1 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 1 1 1
## [3367] 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1
## [3401] 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0
## [3435] 1 0 0 0 0 0 0 1 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0
## [3469] 0 0 1 1 0 0 0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0
## [3503] 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
## [3537] 0 1 1 1 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 1 1 1 0 1 0 0 1 0
## [3571] 0 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 0 1 0 0
## [3605] 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 1
## [3639] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
## [3673] 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 1 0
## [3707] 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0
## [3741] 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0
## [3775] 0 0 1 0 0 0 0 1 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
## [3809] 0 0 0 1 0 0 0 1 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0
```

```
## [3843] 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 1 1 0 1 0 0
## [3877] 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 1
## [3911] 1 0 0 0 0 0 1 1 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0
## [3945] 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0
## [3979] 0 0 1 0 0 0 0 1 0 0 0 1 1 0 1 1 0 0 1 0 1 1 0 1 1 0 0 0 1 0 0 0 0 0
## [4013] 0 1 0 1 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0
## [4047] 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 1 1 0 0 0 0 0 1 0 1 0 0
## [4081] 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 1 0 1 0 1 0 0 1 0 0 0 0 0 0
## [4115] 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 1 1 0 1
## [4149] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0
## [4183] 0 1 0 0 0 1 1 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [4217] 0 1 0 0 0 1 0 0 1 0 1 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
## [4251] 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 0 1
## [4285] 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [4319] 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1
## [4353] 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0 1 1 0 0 0 1 0 0 0
## [4387] 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [4421] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0
## [4455] 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [4489] 0 0 0 0 1 0 1 0 0 1 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0
## [4523] 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 1 1
## [4557] 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 0 1 0 1 0 1 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0
## [4591] 1 0 1 0 1 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0
## [4625] 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0
## [4659] 0 1 0 0 0 0 0 0 0 0 1 1 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0
## [4693] 0 1 0 0 0 1 0 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0
## [4727] 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0
## [4761] 0 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 1 0 0
## [4795] 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [4829] 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 1 1 0 1 0 1 0 0 1 0
## [4863] 1 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0
## [4897] 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 0
## [4931] 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 1 1 1 0 0 0 0 0
## [4965] 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 1
## [4999] 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
## [5033] 0 0 1 0 0 0 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0
## [5067] 0 1 1 0 0 1 0 0 0 1 0 1 1 0 1 0 0 0 1 1 0 0 0 0 0 0 1 0 0 1 0 0 1
## [5101] 0 1 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 0 0
## [5135] 0 1 1 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0
## [5169] 0 1 0 1 0 0 0 0 0 1 0 1 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0
## [5203] 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 1
## [5237] 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0
## [5271] 0 0 0 1 1 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
## [5305] 1 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
## [5339] 1 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1
## [5373] 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 1 0 1 0 0 0 0 0 1 1 0 0 0 0 1 0
## [5407] 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0
## [5441] 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0
## [5475] 1 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
## [5509] 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0
## [5543] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 1 0
## [5577] 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0
## [5611] 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
## [5645] 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 0
```

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```
## [5679] 0 0 0 1 1 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 1 1 0 0 0 0 1 0
## [5713] 0 0 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0 0
## [5747] 1 0 0 0 1 0 0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
## [5781] 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0
## [5815] 0 1 1 1 0 1 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0
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## [26657] 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 1
## [26691] 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0
## [26725] 0 0 0 0 1 0 0 0 0 1 0 0 1 0 1 1 1 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0
## [26759] 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 0
## [26793] 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0
## [26827] 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 1 0 0 1 0 1 0
## [26861] 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0
## [26895] 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 1 0 0
## [26929] 0 1 1 0 1 0 1 0 1 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
## [26963] 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## [26997] 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0
## [27031] 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0
## [27065] 0 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0
## [27099] 0 0 0 1 0 0 0 1 0 0 0 0 1 1 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 1 0 1
## [27133] 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0
## [27167] 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 0 1 1 0 1 1 0 1 0
## [27201] 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 1 0 0 0 1 1 0 1 0 0 0 1 0 1 0 0 0
## [27235] 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 1 0 0 0 1
## [27269] 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 1 0 0 0
## [27303] 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0
## [27337] 1 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0
## [27371] 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0
## [27405] 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 1 1 0 1 1 0 1 1 0 0 1 0 0 0
## [27439] 0 0 1 1 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0
## [27473] 0 1 0 0 0 0 0 0 1 0 0 1 1 1 0 0 0 0 0 1 0 1 0 0 1 1 0 1 0 0 0 0
## [27507] 1 1 0 1 0 1 0 0 0 0 0 0 0 1 0 1 1 0 0 1 1 0 0 0 0 1 0 1 1 0 0 1
## [27541] 1 0 0 1 0 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0
## [27575] 0 0 0 1 0 1 1 0 0 0 1 1 0 1 0 1 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 1 0
## [27609] 0 0 0 0 1 1 0 1 0 0 1 1 0 0 0 1 0 0 0 1 0 0 1 1 0 0 0 1 0 0 0 0 0 0
## [27643] 0 1 0 0 0 0 0 0 0 0 1 1 0 1 0 0 1 0 1 0 1 1 1 0 0 1 0 1 0 0 1 0 0
## [27677] 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 1 0 1 0
```

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```
## [27711] 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0
## [27745] 0 0 0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0
## [27779] 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 1 0 0 0 0
## [27813] 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 1
## [27847] 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0
## [27881] 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0
## [27915] 0 1 0 1 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0
## [27949] 0 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0
## [27983] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1
## [28017] 1 0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1
## [28051] 0 0 1 0 1 0 0 1 0 1 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 1 0 0 1 0 0
## [28085] 0 0 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 1 0 0
## [28119] 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
## [28153] 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 1
## [28187] 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0
## [28221] 1 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0
## [28255] 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 1 1
## [28289] 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1
## [28323] 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0
## [28357] 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0
## [28391] 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
## [28425] 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0
## [28459] 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 1 0
## [28493] 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0
## [28527] 0 0 0 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1
## [28561] 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0
## [28595] 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0
## [28629] 0 0 0 0 0 1 0 1 0 1 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
## [28663] 1 1 0 1 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 0 1 0 0
## [28697] 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
## [28731] 0 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1
## [28765] 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
## [28799] 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0
## [28833] 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0
## [28867] 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1
## [28901] 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 0 1 0 0 1 0
## [28935] 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0
## [28969] 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 1
## [29003] 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 1 0 1 0 0 1 1 0 1 1 0 0 0 0 1 0 1
## [29037] 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0
## [29071] 0 0 0 0 1 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0
## [29105] 0 1 0 0 1 1 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0
## [29139] 1 0 0 0 0 0 1 0 0 0 0 1 1 1 0 1 1 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0
## [29173] 0 0 0 0 1 0 0 1 1 0 0 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 1 1 0 0 0
## [29207] 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0
## [29241] 1 0 1 0 0 0 0 1 1 1 1 0 0 0 1 1 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0
## [29275] 0 0 0 0 1 0 0 1 0 0 0 0 1 0 0 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0
## [29309] 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0
## [29343] 1 0 0 1 0 0 0 0 0 0 1 0 1 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
## [29377] 1 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
## [29411] 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
## [29445] 1 0 0 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1
## [29479] 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 1
## [29513] 1 0 0 1 1 0 1 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1
```

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```
## [29547] 0 0 1 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 1 1 1 0 1
## [29581] 0 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 1 1 0 1 1 0
## [29615] 1 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 1 0 0 0 0
## [29649] 0 0 1 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 1
## [29683] 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0 1
## [29717] 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 1 0 0 1 1 0 1 0 0 0 0 0 0 1 0 1 1 0 0
## [29751] 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 1 1 0 0 0 0 0
## [29785] 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 1
## [29819] 0 1 0 0 0 1 1 0 0 1 1 0 1 0 0 1 0 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0
## [29853] 0 1 0 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 1
## [29887] 0 0 0 0 0 0 0 0 1 0 1 1 0 1 1 0 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 1 0 1
## [29921] 1 1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0
## [29955] 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 1 0 0 0 0 0
## [29989] 0 0 0 1 0 0 1 0 0 1 1 1
## Levels: 0 1
```

Causal Analysis
Causality of different variables

Causality of SEX
```r
y <- h$default.payment.next.month
x <- model.matrix( default.payment.next.month ~ . -SEX, data = h)
d <- h$SEX
```

##LASSO
Step 1
we set penalty level using the theoretical choice
```r
w <-sd(y)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```r
lambda.theory <- 2*w*sqrt(log(num.features/0.01)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

call Lasso
```r
lassoTheory <- glmnet(x,y,lambda = lambda.theory,family="binomial")
```

```
## Error in glmnet(x, y, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

get the support
```r
supp1 <- support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

Step 1 selected
```r
length(supp1)
```

```
## Error in eval(expr, envir, enclos): object 'supp1' not found
```

```r
colnames(x[,supp1])
```

```
## Error in is.data.frame(x): object 'supp1' not found
```

```r
### controls
###
### Step 2
w <-sd(d)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```r
lambda.theory <- 2*w*sqrt(log(num.features/0.05)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```r
lassoTheory <- glmnet(x,d,lambda = lambda.theory, family ="binomial")
```

```
## Error in glmnet(x, d, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```r
supp2<-support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```r
### Step 2 selected
length(supp2)
```

```
## Error in eval(expr, envir, enclos): object 'supp2' not found
```

```r
### controls
colnames(x[,supp2])
```

```
## Error in is.data.frame(x): object 'supp2' not found
```

```r
###
### Step 3
inthemodel <- unique(c(supp1,supp2)) # unique grabs union
```

```
## Error in unique(c(supp1, supp2)): object 'supp1' not found
```

```r
selectdata <- cBind(d,x[,inthemodel])
```

```
## Error in cBind(d, x[, inthemodel]): could not find function "cBind"
```

```r
selectdata <- as.data.frame(as.matrix(selectdata)) # make it a data.frame
```

```
## Error in as.matrix(selectdata): object 'selectdata' not found
```

```r
dim(selectdata) ## p about half n
```

```
## Error in eval(expr, envir, enclos): object 'selectdata' not found
```

```r
## run a a linear regression of Y on d and all selected
causal_glm <- glm(y~., data=selectdata, family="binomial")
```

```
## Error in is.data.frame(data): object 'selectdata' not found
```

```r
## The theory actually says that the standard SE calc for gamma is correct!
## despite the model selection
summary(causal_glm)$coef["d",]
```

```
## Error in summary(causal_glm): object 'causal_glm' not found
```

```r
#######################################
##### Causality of EDUCATION #######

y <- h$default.payment.next.month
x <- model.matrix( default.payment.next.month ~ . -EDUCATION, data = h)
d <- as.factor(h$EDUCATION)

##LASSO
### Step 1
## we set penalty level using the theoretical choice
w <-sd(y)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```r
lambda.theory <- 2*w*sqrt(log(num.features/0.01)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```r
## call Lasso
lassoTheory <- glmnet(x,y,lambda = lambda.theory,family="binomial")
```

```
## Error in glmnet(x, y, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```r
## get the support
supp1 <- support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 1 selected
length(supp1)
```

```
## Error in eval(expr, envir, enclos): object 'supp1' not found
```

```
colnames(x[,supp1])
```

```
## Error in is.data.frame(x): object 'supp1' not found
```

```
### controls
###
### Step 2
w <-sd(d)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```
lambda.theory <- 2*w*sqrt(log(num.features/0.05)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```
lassoTheory <- glmnet(x,d,lambda = lambda.theory, family ="binomial")
```

```
## Error in glmnet(x, d, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```
supp2<-support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 2 selected
length(supp2)
```

```
## Error in eval(expr, envir, enclos): object 'supp2' not found
```

```
### controls
colnames(x[,supp2])
```

```
## Error in is.data.frame(x): object 'supp2' not found
```

```
###
### Step 3
inthemodel <- unique(c(supp1,supp2)) # unique grabs union
```

```
## Error in unique(c(supp1, supp2)): object 'supp1' not found
```

```r
selectdata <- cBind(d,x[,inthemodel])
```

```
## Error in cBind(d, x[, inthemodel]): could not find function "cBind"
```

```r
selectdata <- as.data.frame(as.matrix(selectdata)) # make it a data.frame
```

```
## Error in as.matrix(selectdata): object 'selectdata' not found
```

```r
dim(selectdata) ## p about half n
```

```
## Error in eval(expr, envir, enclos): object 'selectdata' not found
```

```r
## run a a linear regression of Y on d and all selected
causal_glm <- glm(y~., data=selectdata, family="binomial")
```

```
## Error in is.data.frame(data): object 'selectdata' not found
```

```r
## The theory actually says that the standard SE calc for gamma is correct!
## despite the model selection
summary(causal_glm)$coef["d",]
```

```
## Error in summary(causal_glm): object 'causal_glm' not found
```

```r
####################################
############### AGE #######

y <- h$default.payment.next.month
x <- model.matrix( default.payment.next.month ~ . -AGE, data = h)
d <- h$AGE

##LASSO
### Step 1
## we set penalty level using the theoretical choice
w <-sd(y)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```r
lambda.theory <- 2*w*sqrt(log(num.features/0.01)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```r
## call Lasso
lassoTheory <- glmnet(x,y,lambda = lambda.theory,family="binomial")
```

```
## Error in glmnet(x, y, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```
## get the support
supp1 <- support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 1 selected
length(supp1)
```

```
## Error in eval(expr, envir, enclos): object 'supp1' not found
```

```
colnames(x[,supp1])
```

```
## Error in is.data.frame(x): object 'supp1' not found
```

```
### controls
###
### Step 2
w <-sd(d)
lambda.theory <- 2*w*sqrt(log(num.features/0.05)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```
lassoTheory <- glmnet(x,d,lambda = lambda.theory, family ="binomial")
```

```
## Error in glmnet(x, d, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```
supp2<-support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 2 selected
length(supp2)
```

```
## Error in eval(expr, envir, enclos): object 'supp2' not found
```

```
### controls
colnames(x[,supp2])
```

```
## Error in is.data.frame(x): object 'supp2' not found
```

```
###
### Step 3
inthemodel <- unique(c(supp1,supp2)) # unique grabs union
```

```
## Error in unique(c(supp1, supp2)): object 'supp1' not found
```

```
selectdata <- cBind(d,x[,inthemodel])
```

```
## Error in cBind(d, x[, inthemodel]): could not find function "cBind"
```

```
selectdata <- as.data.frame(as.matrix(selectdata)) # make it a data.frame
```

```
## Error in as.matrix(selectdata): object 'selectdata' not found
```

```
dim(selectdata) ## p about half n
```

```
## Error in eval(expr, envir, enclos): object 'selectdata' not found
```

```
## run a a linear regression of Y on d and all selected
causal_glm <- glm(y~., data=selectdata, family="binomial")
```

```
## Error in is.data.frame(data): object 'selectdata' not found
```

```
## The theory actually says that the standard SE calc for gamma is correct!
## despite the model selection
summary(causal_glm)$coef["d",]
```

```
## Error in summary(causal_glm): object 'causal_glm' not found
```

```
##############################
######## MARRIAGE #############

y <- h$default.payment.next.month
x <- model.matrix( default.payment.next.month ~ . -MARRIAGE, data = h)
d <- h$MARRIAGE

##LASSO
### Step 1
## we set penalty level using the theoretical choice
w <-sd(y)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```
lambda.theory <- 2*w*sqrt(log(num.features/0.01)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```
## call Lasso
lassoTheory <- glmnet(x,y,lambda = lambda.theory,family="binomial")
```

```
## Error in glmnet(x, y, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```
## get the support
supp1 <- support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 1 selected
length(supp1)
```

```
## Error in eval(expr, envir, enclos): object 'supp1' not found
```

```
colnames(x[,supp1])
```

```
## Error in is.data.frame(x): object 'supp1' not found
```

```
### controls
###
### Step 2
w <-sd(d)
```

```
## Warning in var(if (is.vector(x) || is.factor(x)) x else as.double(x), na.rm = na.rm): Calling var(x)
##    Use something like 'all(duplicated(x)[-1L])' to test for a constant vector.
```

```
lambda.theory <- 2*w*sqrt(log(num.features/0.05)/num.n)
```

```
## Error in eval(expr, envir, enclos): object 'num.features' not found
```

```
lassoTheory <- glmnet(x,d,lambda = lambda.theory, family ="binomial")
```

```
## Error in glmnet(x, d, lambda = lambda.theory, family = "binomial"): could not find function "glmnet"
```

```
supp2<-support(lassoTheory$beta)
```

```
## Error in support(lassoTheory$beta): object 'lassoTheory' not found
```

```
### Step 2 selected
length(supp2)
```

```
## Error in eval(expr, envir, enclos): object 'supp2' not found
```

```
### controls
colnames(x[,supp2])
```

```
## Error in is.data.frame(x): object 'supp2' not found
```

```
###
### Step 3
inthemodel <- unique(c(supp1,supp2)) # unique grabs union
```

```
## Error in unique(c(supp1, supp2)): object 'supp1' not found
```

```r
selectdata <- cBind(d,x[,inthemodel])
```

```
## Error in cBind(d, x[, inthemodel]): could not find function "cBind"
```

```r
selectdata <- as.data.frame(as.matrix(selectdata)) # make it a data.frame
```

```
## Error in as.matrix(selectdata): object 'selectdata' not found
```

```r
dim(selectdata) ## p about half n
```

```
## Error in eval(expr, envir, enclos): object 'selectdata' not found
```

```r
## run a a linear regression of Y on d and all selected
causal_glm <- glm(y~., data=selectdata, family="binomial")
```

```
## Error in is.data.frame(data): object 'selectdata' not found
```

```r
## The theory actually says that the standard SE calc for gamma is correct!
## despite the model selection
summary(causal_glm)$coef["d",]
```

```
## Error in summary(causal_glm): object 'causal_glm' not found
```

```r
#################
##############
####

##Regressions
#Lasso
library(glmnet)
```

```
## Loading required package: Matrix
```

```
## Loading required package: foreach
```

```
## Loaded glmnet 2.0-18
```

```r
Mx<- model.matrix(default.payment.next.month ~., data=hwop)[,-1]
My<- hwop$default.payment.next.month
lasso <- glmnet(Mx,My,family="binomial")
lassoCV <- cv.glmnet(Mx,My,family="binomial")
par(mar=c(1.5,1.5,2,1.5))
par(mai=c(1.5,1.5,2,1.5))
plot(lassoCV, main="Fitting Graph for CV Lasso \n \n # of non-zero coefficients  ", xlab = expression(pa
```

Fitting Graph for CV Lasso

of non−zero coefficients
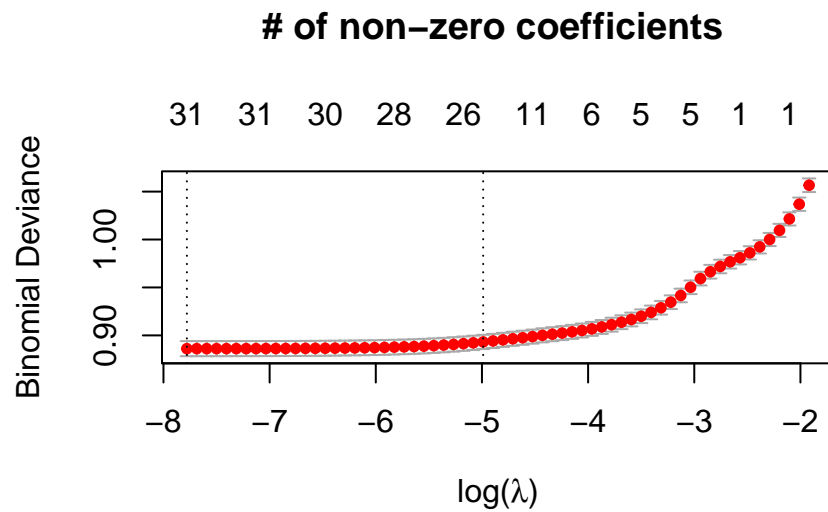

```r
features.min <- support(lasso$beta[,which.min(lassoCV$cvm)])
length(features.min)
```

```
## [1] 21
```

```r
features.1se <- support(lasso$beta[,which.min( (lassoCV$lambda-lassoCV$lambda.1se)^2)])
length(features.1se)
```

```
## [1] 14
```

```r
data.min <- data.frame(Mx[,features.min],My)
data.1se <- data.frame(Mx[,features.1se],My)
head(data.1se)
```

```
##   SEX2 EDUCATION4 EDUCATION5 MARRIAGE1 MARRIAGE2 AGE PAY_00 PAY_01 PAY_02
## 1    1          0          0         1         0  24      0      0      1
## 2    1          0          0         0         1  26      0      0      0
## 3    1          0          0         0         1  34      1      0      0
## 4    1          0          0         1         0  37      1      0      0
## 5    0          0          0         1         0  57      0      0      0
## 6    0          0          0         0         1  37      1      0      0
##   PAY_03 PAY_04 PAY_05 PAY_07 PAY_08 My
## 1      0      0      0      0      0  1
## 2      0      0      0      0      0  1
## 3      0      0      0      0      0  0
## 4      0      0      0      0      0  0
## 5      0      0      0      0      0  0
## 6      0      0      0      0      0  0
```

```r
head(data.min)
```

```
##    SEX2 EDUCATION2 EDUCATION3 EDUCATION4 EDUCATION5 EDUCATION6 MARRIAGE1
## 1     1          1          0          0          0          0         1
## 2     1          1          0          0          0          0         0
## 3     1          1          0          0          0          0         0
## 4     1          1          0          0          0          0         1
## 5     0          1          0          0          0          0         1
## 6     0          0          0          0          0          0         0
##    MARRIAGE3 AGE PAY_0.1 PAY_00 PAY_01 PAY_02 PAY_03 PAY_04 PAY_05 PAY_06
## 1          0  24       0      0      0      1      0      0      0      0
## 2          0  26       1      0      0      0      0      0      0      0
## 3          0  34       0      1      0      0      0      0      0      0
## 4          0  37       0      1      0      0      0      0      0      0
## 5          0  57       1      0      0      0      0      0      0      0
## 6          0  37       0      1      0      0      0      0      0      0
##    PAY_07 PAY_08 PAY_AMT1 PAY_AMT2 My
## 1       0      0        0      689  1
## 2       0      0        0     1000  1
## 3       0      0     1518     1500  0
## 4       0      0     2000     2019  0
## 5       0      0     2000    36681  0
## 6       0      0     2500     1815  0
```

```r
#Insample R squared and Accuracy values forLogistic, Logistic interaction, classification tree, null an
library(tree)
library(SDMTools)
```

```
## Error in library(SDMTools): there is no package called 'SDMTools'
```

```r
inlogint <- glm(default.payment.next.month~.^2, data=hwop,family="binomial")
```

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

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

```r
inlog <-glm(default.payment.next.month~., data=hwop,family="binomial")
```

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

```r
inloglasso <- glm(My~., data=data.1se,family="binomial")
inctree <- tree(default.payment.next.month~., data=hwop)
inlnull <- glm(default.payment.next.month ~1,data=hwop,family="binomial")
summary(inlog)
```

```
##
## Call:
## glm(formula = default.payment.next.month ~ ., family = "binomial",
##     data = hwop)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.9062  -0.6069  -0.5265  -0.2964   3.6965
```

```
## 
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.321e+01  8.421e+01  -0.157  0.87535
## LIMIT_BAL   -2.326e-06  1.666e-07 -13.959  < 2e-16 ***
## SEX2        -1.672e-01  3.186e-02  -5.248 1.54e-07 ***
## EDUCATION1   1.085e+01  8.420e+01   0.129  0.89744
## EDUCATION2   1.088e+01  8.420e+01   0.129  0.89718
## EDUCATION3   1.083e+01  8.420e+01   0.129  0.89770
## EDUCATION4   9.642e+00  8.421e+01   0.115  0.90883
## EDUCATION5   9.450e+00  8.421e+01   0.112  0.91065
## EDUCATION6   1.048e+01  8.421e+01   0.124  0.90098
## MARRIAGE1    1.270e+00  5.011e-01   2.534  0.01128 *
## MARRIAGE2    1.111e+00  5.012e-01   2.217  0.02661 *
## MARRIAGE3    1.281e+00  5.201e-01   2.463  0.01376 *
## AGE          3.494e-03  1.942e-03   1.800  0.07191 .
## PAY_0-1      1.644e-01  6.775e-02   2.426  0.01525 *
## PAY_00      -4.496e-01  6.819e-02  -6.593 4.30e-11 ***
## PAY_01       8.233e-01  6.942e-02  11.859  < 2e-16 ***
## PAY_02       2.160e+00  7.668e-02  28.170  < 2e-16 ***
## PAY_03       2.423e+00  1.455e-01  16.656  < 2e-16 ***
## PAY_04       1.960e+00  2.576e-01   7.610 2.74e-14 ***
## PAY_05       1.242e+00  4.053e-01   3.063  0.00219 **
## PAY_06       1.372e+00  6.126e-01   2.239  0.02516 *
## PAY_07       2.259e+00  8.072e-01   2.799  0.00513 **
## PAY_08       1.332e+00  4.720e-01   2.822  0.00477 **
## BILL_AMT1   -1.961e-06  1.112e-06  -1.763  0.07783 .
## BILL_AMT2    2.179e-06  1.479e-06   1.473  0.14064
## BILL_AMT3    1.869e-06  1.339e-06   1.396  0.16274
## BILL_AMT4    1.472e-07  1.367e-06   0.108  0.91430
## BILL_AMT5    2.966e-07  1.545e-06   0.192  0.84779
## BILL_AMT6    7.079e-07  1.204e-06   0.588  0.55669
## PAY_AMT1    -1.279e-05  2.261e-06  -5.658 1.53e-08 ***
## PAY_AMT2    -1.118e-05  2.164e-06  -5.167 2.38e-07 ***
## PAY_AMT3    -3.529e-06  1.745e-06  -2.022  0.04313 *
## PAY_AMT4    -4.256e-06  1.832e-06  -2.323  0.02019 *
## PAY_AMT5    -4.185e-06  1.813e-06  -2.308  0.02100 *
## PAY_AMT6    -2.684e-06  1.343e-06  -1.998  0.04569 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## (Dispersion parameter for binomial family taken to be 1)
## 
##     Null deviance: 31705  on 29999  degrees of freedom
## Residual deviance: 26493  on 29965  degrees of freedom
## AIC: 26563
## 
## Number of Fisher Scoring iterations: 11
```

```r
inlogintr <- R2(y=hwop$default.payment.next.month, pred=inlogint$fitted.values,family="binomial" )
inlogr <- R2(y=hwop$default.payment.next.month, pred=inlog$fitted.values,family="binomial" )
inloglassor <- R2(y=data.1se$My, pred=inloglasso$fitted.values,family="binomial")
inctreer <- R2(y=hwop$default.payment.next.month, pred=predict(inctree, newdata=hwop, type="vector")[,2]
innullr <- R2(y=hwop$default.payment.next.month, pred=inlnull$fitted.values,family="binomial" )
```

```r
##Accuracy calculated at a threshold value of 0.75
Acclogint <-accuracy(hwop$default.payment.next.month,inlogint$fitted.values,threshold = 0.75)$prop.corre

## Error in accuracy(hwop$default.payment.next.month, inlogint$fitted.values, : could not find function

Acclog <- accuracy(hwop$default.payment.next.month, pred=inlog$fitted.values,threshold = 0.75)$prop.cor

## Error in accuracy(hwop$default.payment.next.month, pred = inlog$fitted.values, : could not find funct

Accloglasso <- accuracy(data.1se$My, pred=inloglasso$fitted.values,threshold = 0.75)$prop.correct

## Error in accuracy(data.1se$My, pred = inloglasso$fitted.values, threshold = 0.75): could not find fu

Accctree <- accuracy(hwop$default.payment.next.month,pred=predict(inctree, newdata=hwop, type="vector")

## Error in accuracy(hwop$default.payment.next.month, pred = predict(inctree, : could not find function

Accnull <- accuracy(hwop$default.payment.next.month, pred=inlnull$fitted.values,threshold = 0.75)$prop.

## Error in accuracy(hwop$default.payment.next.month, pred = inlnull$fitted.values, : could not find fu

##kfold for OOS R squared and Accuracy
nfold <- 5
n <- nrow(hwop)
foldid <- rep(1:nfold,each=ceiling(n/nfold))[sample(1:n)]
### create an empty dataframe of results to store the OOS R-squared and Accuracy
OOS <- data.frame(logint=rep(NA,nfold),log=rep(NA,nfold),null=rep(NA,nfold),loglasso=rep(NA,nfold),ctre
Acc <- data.frame(logint=rep(NA,nfold),log=rep(NA,nfold),null=rep(NA,nfold),loglasso=rep(NA,nfold),ctre
### Use a for loop to run through the nfold trails
for(k in 1:nfold){
  traink <- which(foldid!=k)
  logint <- glm(default.payment.next.month~.^2, data=hwop,subset=traink,family="binomial")
  log <-glm(default.payment.next.month~., data=hwop,subset=traink,family="binomial")
  loglasso <- glm(My~., data=data.1se,family="binomial",subset=traink)
  ctree <- tree(default.payment.next.month~., data=hwop,subset=traink)
  lnull <- glm(default.payment.next.month ~1,data=hwop,subset=traink,family="binomial")

  ## get predictions
  oologint <- predict(logint, newdata=hwop[-traink,],type="response")
  oolog   <- predict(log, newdata=hwop[-traink,],type="response")
  oologlasso <- predict(loglasso, newdata=data.1se[-traink,],type="response")
  ooctree <- predict(ctree, newdata=hwop[-traink,],type="vector")
  oolnull <- predict(lnull, newdata=hwop[-traink,],type="response")

  ## calculate and log OOS R2 for each fold k
  OOS$logint[k] <- R2(y=hwop$default.payment.next.month[-traink], pred=oologint,family="binomial" )
  OOS$log[k] <- R2(y=hwop$default.payment.next.month[-traink], pred=oolog,family="binomial")
  OOS$ctree[k] <- R2(y=hwop$default.payment.next.month[-traink], pred=ooctree, family="binomial")
  OOS$loglasso[k] <- R2(y=data.1se$My[-traink], pred=oologlasso,family="binomial")
```

```
  OOS$null[k] <- R2(y=hwop$default.payment.next.month[-traink], pred=oolnull,family="binomial")

  ##Accuracy for each fold k
  Acc$logint[k] <-accuracy(hwop$default.payment.next.month[-traink],oologint,threshold = 0.75)$prop.cor
  Acc$log[k] <- accuracy(hwop$default.payment.next.month[-traink], pred=oolog,threshold = 0.75)$prop.co
  Acc$loglasso[k] <- accuracy(data.1se$My[-traink], pred=oologlasso,threshold = 0.75)$prop.correct
  Acc$ctree[k] <- accuracy(hwop$default.payment.next.month[-traink],pred=ooctree[,2],threshold = 0.75)$
  Acc$null[k] <- accuracy(hwop$default.payment.next.month[-traink], pred=oolnull,threshold = 0.75)$prop

  ## We will loop this nfold times
  ## this will print the progress (iteration that finished)
  print(paste("Iteration",k,"of",nfold))
}
```

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

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

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

## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
## ifelse(type == : prediction from a rank-deficient fit may be misleading

## Error in accuracy(hwop$default.payment.next.month[-traink], oologint, : could not find function "accu
```

```
## OOS R- squared matrix for all the different models and fgolds
colMeans(OOS)
```

```
##   logint      log     null loglasso    ctree
##       NA       NA       NA       NA       NA
```

```
colMeans(Acc)
```

```
##   logint      log     null loglasso    ctree
##       NA       NA       NA       NA       NA
```

```
m.OOS <- as.matrix(OOS)
rownames(m.OOS) <- c(1:nfold)
barplot(t(as.matrix(OOS)), beside=TRUE, legend=TRUE, args.legend=c(xjust=1, yjust=-0.03),
        ylab= bquote( "Out of Sample " ~ R^2), xlab="Fold", names.arg = c(1:5),ylim=c(-2,0.3))
```

```
m.ACC <- as.matrix(Acc)
rownames(m.ACC) <- c(1:nfold)
barplot(t(as.matrix(Acc)), beside=TRUE, legend=TRUE, args.legend=c(xjust=1, yjust=-0.01),
        ylab= bquote( "Out of Sample " ~ Accuracy), xlab="Fold", names.arg = c(1:5),ylim=c(0,1))
```
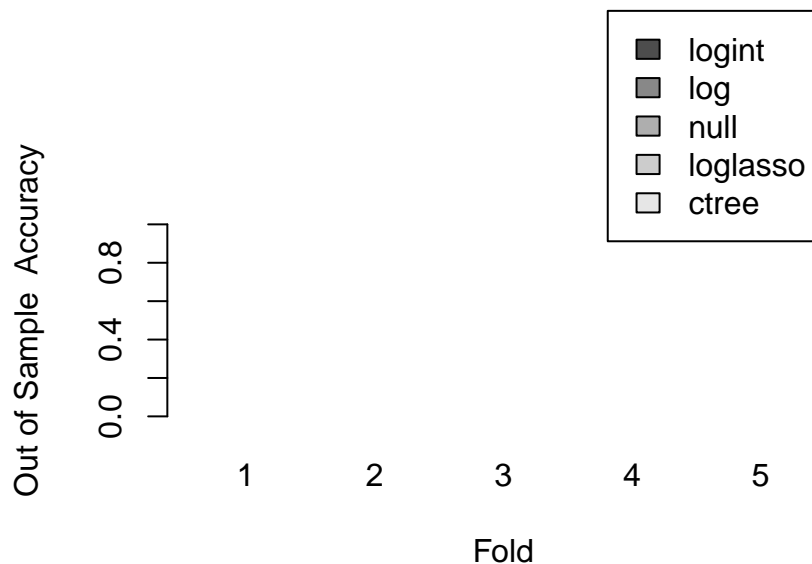


```
## ############################### XGBoost
## Data balancing using SMOTE method
set.seed(1900)
inTrain <- createDataPartition(y=ccdata_Total$Target, p=0.6, list=F)
```

```
## Error in createDataPartition(y = ccdata_Total$Target, p = 0.6, list = F): could not find function "c
```

```
train <- ccdata_Total[inTrain,]
```

```
## Error in eval(expr, envir, enclos): object 'ccdata_Total' not found
```

```
table(train$Target)
```

```
## Error in table(train$Target): object 'train' not found
```

```
testcv <- ccdata_Total[-inTrain,]
```

```
## Error in eval(expr, envir, enclos): object 'ccdata_Total' not found
```

```
inTest <- createDataPartition(y=testcv$Target, p=0.5, list=F)
```

```
## Error in createDataPartition(y = testcv$Target, p = 0.5, list = F): could not find function "createD
```

```
test <- testcv[inTest,]
```

```
## Error in eval(expr, envir, enclos): object 'testcv' not found
```

```
cv <- testcv[-inTest,]
```

```
## Error in eval(expr, envir, enclos): object 'testcv' not found
```

```
rm(inTrain, inTest, testcv)
```

```
## Warning in rm(inTrain, inTest, testcv): object 'inTrain' not found
```

```
## Warning in rm(inTrain, inTest, testcv): object 'inTest' not found
```

```
## Warning in rm(inTrain, inTest, testcv): object 'testcv' not found
```

```
i <- grep("Target", colnames(train)) # Get index Class column
```

```
## Error in is.data.frame(x): object 'train' not found
```

```
train_smote <- SMOTE(Target~., as.data.frame(train),perc.over=2500, perc.under=100)
```

```
## Error in SMOTE(Target ~ ., as.data.frame(train), perc.over = 2500, perc.under = 100): could not find
```

```
table(train_smote$Target)
```

```
## Error in table(train_smote$Target): object 'train_smote' not found
```

```r
# Back to numeric
train$Target <- as.numeric(levels(train$Target))[train$Target]
```

```
## Error in levels(train$Target): object 'train' not found
```

```r
train_smote$Target <- as.numeric(levels(train_smote$Target))[train_smote$Target]
```

```
## Error in levels(train_smote$Target): object 'train_smote' not found
```

```r
# As Matrix
train <- Matrix(as.matrix(train), sparse = TRUE)
```

```
## Error in as.matrix(train): object 'train' not found
```

```r
train_smote <- Matrix(as.matrix(train_smote), sparse = TRUE)
```

```
## Error in as.matrix(train_smote): object 'train_smote' not found
```

```r
test <- Matrix(as.matrix(test), sparse = TRUE)
```

```
## Error in as.matrix(test): object 'test' not found
```

```r
cv <- Matrix(as.matrix(cv), sparse = TRUE)
```

```
## Error in as.matrix(cv): object 'cv' not found
```

```r
# Create XGB Matrices
train_xgb <- xgb.DMatrix(data = train[,-i], label = train[,i])
```

```
## Error in xgb.DMatrix(data = train[, -i], label = train[, i]): could not find function "xgb.DMatrix"
```

```r
train_smote_xgb <- xgb.DMatrix(data = train_smote[,-i], label = train_smote[,i])
```

```
## Error in xgb.DMatrix(data = train_smote[, -i], label = train_smote[, i]): could not find function "xg
```

```r
test_xgb <- xgb.DMatrix(data = test[,-i], label = test[,i])
```

```
## Error in xgb.DMatrix(data = test[, -i], label = test[, i]): could not find function "xgb.DMatrix"
```

```r
cv_xgb <- xgb.DMatrix(data = cv[,-i], label = cv[,i])
```

```
## Error in xgb.DMatrix(data = cv[, -i], label = cv[, i]): could not find function "xgb.DMatrix"
```

```r
# Watchlist
watchlist <- list(train  = train_xgb, cv = cv_xgb)
```

```
## Error in eval(expr, envir, enclos): object 'train_xgb' not found
```

```r
# set parameters:
parameters <- list(
  # General Parameters
  booster            = "gbtree",
  silent             = 0,
  # Booster Parameters
  eta                = 0.3,
  gamma              = 0,
  max_depth          = 6,
  min_child_weight   = 1,
  subsample          = 1,
  colsample_bytree   = 1,
  colsample_bylevel  = 1,
  lambda             = 1,
  alpha              = 0,
  # Task Parameters
  objective          = "binary:logistic",
  eval_metric        = "auc",
  seed               = 1900
)


# Train model
# Original
xgb.model <- xgb.train(parameters, train_xgb, nrounds = 50, watchlist)
```

```
## Error in xgb.train(parameters, train_xgb, nrounds = 50, watchlist): could not find function "xgb.trai
```

```r
#Plot:
melted <- melt(xgb.model$evaluation_log, id.vars="iter")
```

```
## Error in melt(xgb.model$evaluation_log, id.vars = "iter"): could not find function "melt"
```

```r
ggplot(data=melted, aes(x=iter, y=value, group=variable, color = variable)) + geom_line()
```

```
## Error in ggplot(data = melted, aes(x = iter, y = value, group = variable, : object 'melted' not foun
```

```r
# Smote
xgb_smote.model <- xgb.train(parameters, train_smote_xgb, nrounds = 50, watchlist)
```

```
## Error in xgb.train(parameters, train_smote_xgb, nrounds = 50, watchlist): could not find function "xg
```

```r
#Plot:
melted <- melt(xgb_smote.model$evaluation_log, id.vars="iter")
```

```
## Error in melt(xgb_smote.model$evaluation_log, id.vars = "iter"): could not find function "melt"
```

```r
ggplot(data=melted, aes(x=iter, y=value, group=variable, color = variable)) + geom_line()
```

```
## Error in ggplot(data = melted, aes(x = iter, y = value, group = variable, : object 'melted' not found
```