Bank_Marketing_PCA.R

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```
bank <- read.csv("~/Documents/Study/Semester2/
Multivariate/bank-additional/bank-additional-full.csv",
sep=";")
bank_marketing <- bank
head(bank_marketing)
```

```
##   age       job marital   education default housing
loan   contact month
## 1  56 housemaid married    basic.4y      no      no
no telephone   may
## 2  57  services married high.school unknown      no
no telephone   may
## 3  37  services married high.school      no     yes
no telephone   may
## 4  40    admin. married    basic.6y      no      no
no telephone   may
## 5  56  services married high.school      no      no
yes telephone   may
## 6  45  services married    basic.9y unknown      no
no telephone   may
##   day_of_week duration campaign pdays previous
poutcome emp.var.rate
## 1         mon      261        1   999        0
nonexistent          1.1
## 2         mon      149        1   999        0
nonexistent          1.1
## 3         mon      226        1   999        0
nonexistent          1.1
## 4         mon      151        1   999        0
nonexistent          1.1
## 5         mon      307        1   999        0
```

```
nonexistent          1.1
## 6         mon      198         1   999         0
nonexistent          1.1
##   cons.price.idx cons.conf.idx euribor3m nr.employed
y
## 1         93.994         -36.4     4.857        5191
no
## 2         93.994         -36.4     4.857        5191
no
## 3         93.994         -36.4     4.857        5191
no
## 4         93.994         -36.4     4.857        5191
no
## 5         93.994         -36.4     4.857        5191
no
## 6         93.994         -36.4     4.857        5191
no
```

```
str(bank_marketing)
```

```
## 'data.frame':    41188 obs. of  21 variables:
##  $ age           : int  56 57 37 40 56 45 59 41 24
25 ...
##  $ job           : Factor w/ 12 levels
"admin.","blue-collar",..: 4 8 8 1 8 8 1 2 10 8 ...
##  $ marital       : Factor w/ 4 levels
"divorced","married",..: 2 2 2 2 2 2 2 2 3 3 ...
##  $ education     : Factor w/ 8 levels "basic.
4y","basic.6y",..: 1 4 4 2 4 3 6 8 6 4 ...
##  $ default       : Factor w/ 3 levels
"no","unknown",..: 1 2 1 1 1 2 1 2 1 1 ...
##  $ housing       : Factor w/ 3 levels
"no","unknown",..: 1 1 3 1 1 1 1 1 3 3 ...
##  $ loan          : Factor w/ 3 levels
"no","unknown",..: 1 1 1 1 3 1 1 1 1 1 ...
##  $ contact       : Factor w/ 2 levels
"cellular","telephone": 2 2 2 2 2 2 2 2 2 2 ...
##  $ month         : Factor w/ 10 levels
```

```
"apr","aug","dec",..: 7 7 7 7 7 7 7 7 7 7 ...
##  $ day_of_week   : Factor w/ 5 levels
"fri","mon","thu",..: 2 2 2 2 2 2 2 2 2 2 ...
##  $ duration      : int  261 149 226 151 307 198 139
217 380 50 ...
##  $ campaign      : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ pdays         : int  999 999 999 999 999 999 999
999 999 999 ...
##  $ previous      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ poutcome      : Factor w/ 3 levels
"failure","nonexistent",..: 2 2 2 2 2 2 2 2 2 2 ...
##  $ emp.var.rate  : num  1.1 1.1 1.1 1.1 1.1 1.1 1.1
1.1 1.1 1.1 ...
##  $ cons.price.idx: num  94 94 94 94 94 ...
##  $ cons.conf.idx : num  -36.4 -36.4 -36.4 -36.4
-36.4 -36.4 -36.4 -36.4 -36.4 -36.4 ...
##  $ euribor3m     : num  4.86 4.86 4.86 4.86 4.86 ...
##  $ nr.employed   : num  5191 5191 5191 5191 5191 ...
##  $ y             : Factor w/ 2 levels "no","yes": 1
1 1 1 1 1 1 1 1 1 ...
```

```
bank_marketing_pca=bank_marketing[,c(1,11:14,16:20)]
str(bank_marketing_pca)
```

```
## 'data.frame':    41188 obs. of  10 variables:
##  $ age           : int  56 57 37 40 56 45 59 41 24
25 ...
##  $ duration      : int  261 149 226 151 307 198 139
217 380 50 ...
##  $ campaign      : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ pdays         : int  999 999 999 999 999 999 999
999 999 999 ...
##  $ previous      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ emp.var.rate  : num  1.1 1.1 1.1 1.1 1.1 1.1 1.1
1.1 1.1 1.1 ...
##  $ cons.price.idx: num  94 94 94 94 94 ...
##  $ cons.conf.idx : num  -36.4 -36.4 -36.4 -36.4
-36.4 -36.4 -36.4 -36.4 -36.4 -36.4 ...
```

```
##  $ euribor3m     : num  4.86 4.86 4.86 4.86 4.86 ...
##  $ nr.employed   : num  5191 5191 5191 5191 5191 ...
summary(bank_marketing_pca)
##       age           duration         campaign
pdays
##  Min.   :17.00   Min.   :   0.0   Min.   : 1.000
Min.   :  0.0
##  1st Qu.:32.00   1st Qu.: 102.0   1st Qu.: 1.000
1st Qu.:999.0
##  Median :38.00   Median : 180.0   Median : 2.000
Median :999.0
##  Mean   :40.02   Mean   : 258.3   Mean   : 2.568
Mean   :962.5
##  3rd Qu.:47.00   3rd Qu.: 319.0   3rd Qu.: 3.000
3rd Qu.:999.0
##  Max.   :98.00   Max.   :4918.0   Max.   :56.000
Max.   :999.0
##     previous      emp.var.rate      cons.price.idx
cons.conf.idx
##  Min.   :0.000   Min.   :-3.40000   Min.   :92.20
Min.   :-50.8
##  1st Qu.:0.000   1st Qu.:-1.80000   1st Qu.:93.08
1st Qu.:-42.7
##  Median :0.000   Median : 1.10000   Median :93.75
Median :-41.8
##  Mean   :0.173   Mean   : 0.08189   Mean   :93.58
Mean   :-40.5
##  3rd Qu.:0.000   3rd Qu.: 1.40000   3rd Qu.:93.99
3rd Qu.:-36.4
##  Max.   :7.000   Max.   : 1.40000   Max.   :94.77
Max.   :-26.9
##    euribor3m      nr.employed
##  Min.   :0.634   Min.   :4964
##  1st Qu.:1.344   1st Qu.:5099
##  Median :4.857   Median :5191
##  Mean   :3.621   Mean   :5167
```

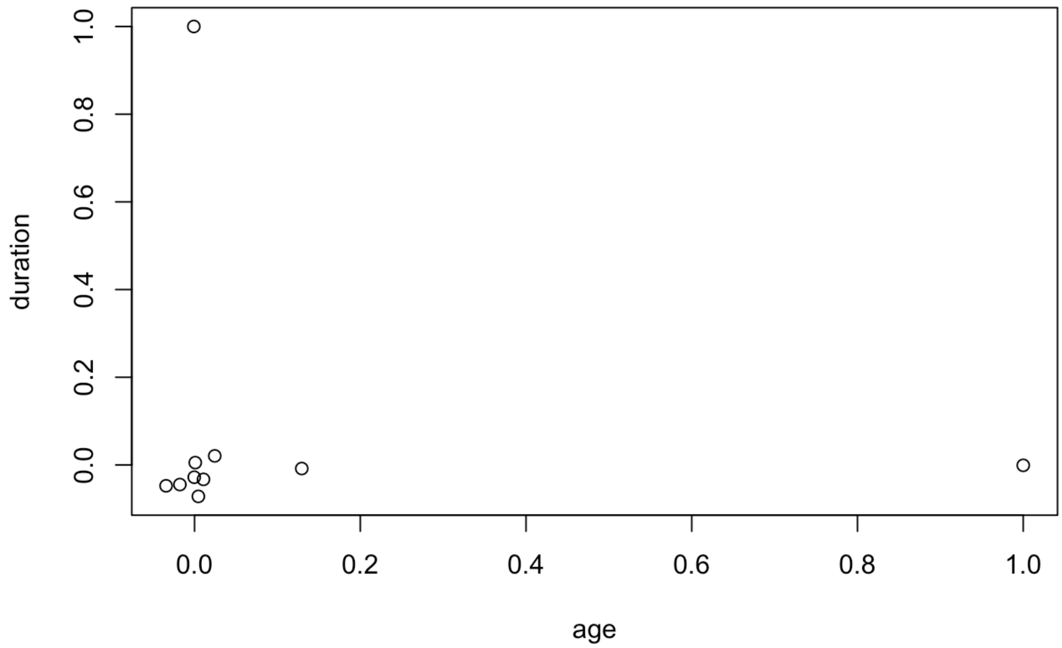
```
##  3rd Qu.:4.961   3rd Qu.:5228
##  Max.   :5.045   Max.   :5228
```

```
cor(bank_marketing_pca)
```

```
##                            age     duration
campaign       pdays
## age              1.0000000000 -0.000865705
0.00459358 -0.03436895
## duration        -0.0008657050  1.000000000
-0.07169923 -0.04757702
## campaign         0.0045935805 -0.071699226
1.00000000  0.05258357
## pdays           -0.0343689512 -0.047577015
0.05258357  1.00000000
## previous         0.0243647409  0.020640351
-0.07914147 -0.58751386
## emp.var.rate    -0.0003706855 -0.027967884
0.15075381  0.27100417
## cons.price.idx  0.0008567150  0.005312268
0.12783591  0.07888911
## cons.conf.idx   0.1293716142 -0.008172873
-0.01373310 -0.09134235
## euribor3m        0.0107674295 -0.032896656
0.13513251  0.29689911
## nr.employed     -0.0177251319 -0.044703223
0.14409489  0.37260474
##                     previous  emp.var.rate
cons.price.idx cons.conf.idx
## age              0.02436474 -0.0003706855
0.000856715   0.129371614
## duration         0.02064035 -0.0279678845
0.005312268  -0.008172873
## campaign        -0.07914147  0.1507538056
0.127835912  -0.013733099
## pdays           -0.58751386  0.2710041743
0.078889109  -0.091342354
## previous         1.00000000 -0.4204891094
```

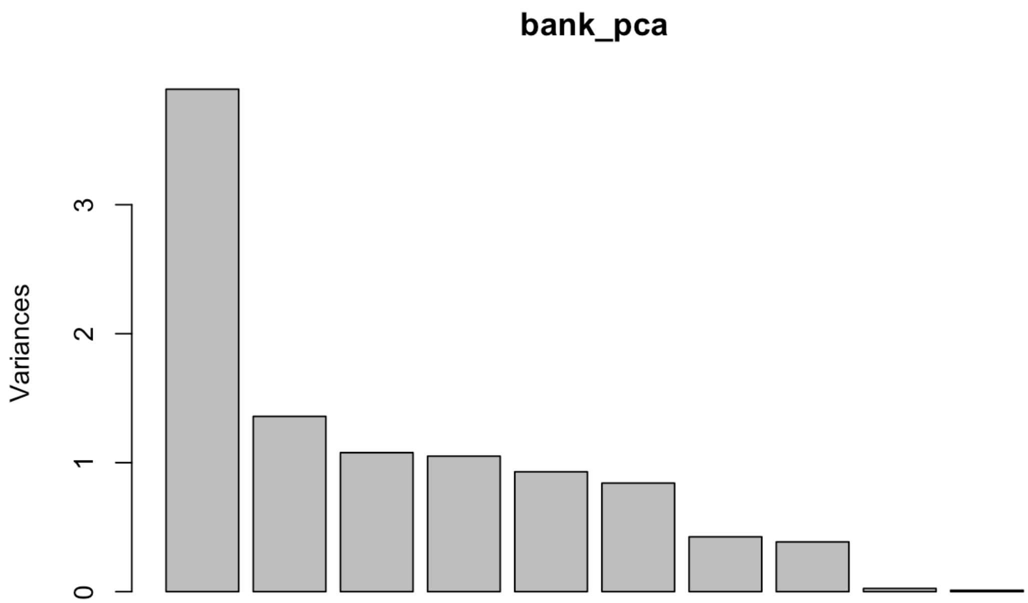
```
-0.203129967  -0.050936351
## emp.var.rate   -0.42048911  1.0000000000
0.775334171   0.196041268
## cons.price.idx -0.20312997  0.7753341708
1.000000000   0.058986182
## cons.conf.idx  -0.05093635  0.1960412681
0.058986182   1.000000000
## euribor3m      -0.45449365  0.9722446712
0.688230107   0.277686220
## nr.employed    -0.50133293  0.9069701013
0.522033977   0.100513432
##                 euribor3m nr.employed
## age             0.01076743 -0.01772513
## duration       -0.03289666 -0.04470322
## campaign        0.13513251  0.14409489
## pdays           0.29689911  0.37260474
## previous       -0.45449365 -0.50133293
## emp.var.rate    0.97224467  0.90697010
## cons.price.idx  0.68823011  0.52203398
## cons.conf.idx   0.27768622  0.10051343
## euribor3m       1.00000000  0.94515443
## nr.employed     0.94515443  1.00000000
```

```
plot(cor(bank_marketing_pca))
```




```
# Using prcomp to compute the principal components
(eigenvalues and eigenvectors). With scale=TRUE,
variable means are set to zero, and variances set to
one

bank_pca <- prcomp(bank_marketing_pca,scale=TRUE)
plot(bank_pca)
```




```
summary(bank_pca)
## Importance of components:
##                           PC1    PC2    PC3    PC4
PC5     PC6     PC7
## Standard deviation     1.9737 1.1657 1.0381 1.0249
0.96408 0.91751 0.65201
## Proportion of Variance 0.3896 0.1359 0.1078 0.1050
0.09295 0.08418 0.04251
## Cumulative Proportion  0.3896 0.5254 0.6332 0.7382
0.83118 0.91537 0.95788
##                            PC8     PC9    PC10
## Standard deviation     0.62106 0.15776 0.10298
## Proportion of Variance 0.03857 0.00249 0.00106
## Cumulative Proportion  0.99645 0.99894 1.00000
# x has new values of data , after
(eigen_bank <- bank_pca$sdev^2)
##  [1] 3.89549575 1.35888318 1.07764506 1.05036054
0.92945344 0.84183259
##  [7] 0.42511495 0.38572154 0.02488887 0.01060409
```

```
names(eigen_bank) <- paste("PC",1:10,sep="")
eigen_bank
```

```
##        PC1        PC2        PC3        PC4
PC5        PC6
## 3.89549575 1.35888318 1.07764506 1.05036054
0.92945344 0.84183259
##        PC7        PC8        PC9       PC10
## 0.42511495 0.38572154 0.02488887 0.01060409
```

```
sumlambdas <- sum(eigen_bank)
sumlambdas
```

```
## [1] 10
```

```
propvar <- eigen_bank/sumlambdas
propvar
```

```
##         PC1         PC2         PC3         PC4
PC5         PC6
## 0.389549575 0.135888318 0.107764506 0.105036054
0.092945344 0.084183259
##         PC7         PC8         PC9        PC10
## 0.042511495 0.038572154 0.002488887 0.001060409
```

```
cumvar_bank <- cumsum(propvar)
cumvar_bank
```

```
##       PC1       PC2       PC3       PC4       PC5
PC6       PC7
## 0.3895496 0.5254379 0.6332024 0.7382385 0.8311838
0.9153671 0.9578786
##       PC8       PC9      PC10
## 0.9964507 0.9989396 1.0000000
```

```
matlambdas <- rbind(eigen_bank,propvar,cumvar_bank)
rownames(matlambdas) <- c("Eigenvalues","Prop.
variance","Cum. prop. variance")
round(matlambdas,4)
```

```
##                        PC1    PC2    PC3    PC4
PC5    PC6    PC7
## Eigenvalues         3.8955 1.3589 1.0776 1.0504
0.9295 0.8418 0.4251
## Prop. variance      0.3895 0.1359 0.1078 0.1050
```

```
0.0929 0.0842 0.0425
## Cum. prop. variance 0.3895 0.5254 0.6332 0.7382
0.8312 0.9154 0.9579
##                         PC8    PC9   PC10
## Eigenvalues         0.3857 0.0249 0.0106
## Prop. variance      0.0386 0.0025 0.0011
## Cum. prop. variance 0.9965 0.9989 1.0000
```

```
summary(bank_pca)
```

```
## Importance of components:
##                           PC1    PC2    PC3    PC4
PC5     PC6     PC7
## Standard deviation     1.9737 1.1657 1.0381 1.0249
0.96408 0.91751 0.65201
## Proportion of Variance 0.3896 0.1359 0.1078 0.1050
0.09295 0.08418 0.04251
## Cumulative Proportion  0.3896 0.5254 0.6332 0.7382
0.83118 0.91537 0.95788
##                            PC8     PC9    PC10
## Standard deviation     0.62106 0.15776 0.10298
## Proportion of Variance 0.03857 0.00249 0.00106
## Cumulative Proportion  0.99645 0.99894 1.00000
```

```
bank_pca$rotation
```

```
##                         PC1          PC2
PC3          PC4
## age            -0.001577131  0.251900655
0.635282811 -0.253370761
## duration       -0.025564414  0.081409042
0.040921453  0.767885976
## campaign        0.100490892 -0.007934948
-0.324028903 -0.575546022
## pdays           0.227536614 -0.628711981
0.252674001 -0.006719777
## previous       -0.305815059  0.474453454
-0.281754824 -0.021267326
## emp.var.rate    0.488002497  0.163001272
-0.091015114  0.044439336
```

```
## cons.price.idx  0.366097505  0.279060437
-0.276172371  0.073400593
## cons.conf.idx   0.101572714  0.427668539
0.510937020 -0.070490333
## euribor3m       0.490377105  0.148132110
-0.002732445  0.036446035
## nr.employed     0.470094939 -0.013534619
-0.029958110  0.027276466
##                         PC5          PC6          PC7
PC8
## age             0.44501766 -0.519053816  0.03130209
-0.017883104
## duration        0.59089472  0.222453386  0.03759640
0.036557378
## campaign        0.61975410  0.411271670  0.00457756
0.015618439
## pdays           0.05446567  0.017271037 -0.22220217
0.660616627
## previous       -0.03416913 -0.146373752  0.19252528
0.735882396
## emp.var.rate   -0.03068934 -0.075546254  0.07039768
0.047342403
## cons.price.idx  0.04059256 -0.249851072 -0.73172135
0.003923396
## cons.conf.idx  -0.23898992  0.647573823 -0.17299928
0.120583312
## euribor3m      -0.06312538  0.004006082  0.21662283
0.052635324
## nr.employed    -0.02971432 -0.052239619  0.54214369
0.024394248
##                          PC9          PC10
## age             1.877379e-03  0.0013597361
## duration       -1.291328e-03  0.0013824218
## campaign        1.144203e-05 -0.0092865724
## pdays           2.347902e-03  0.0007657793
## previous       -1.826083e-02  0.0042240094
```

```
## emp.var.rate    7.938804e-01  0.2844876703
## cons.price.idx -3.114171e-01  0.0997677428
## cons.conf.idx  -7.079644e-02  0.1216873967
## euribor3m      -6.342829e-02 -0.8237302095
## nr.employed    -5.132191e-01  0.4643979470
print(bank_pca)
## Standard deviations (1, .., p=10):
##  [1] 1.9737010 1.1657114 1.0380968 1.0248710
0.9640817 0.9175144 0.6520084
##  [8] 0.6210648 0.1577621 0.1029762
##
## Rotation (n x k) = (10 x 10):
##                          PC1          PC2
PC3          PC4
## age            -0.001577131  0.251900655
0.635282811 -0.253370761
## duration       -0.025564414  0.081409042
0.040921453  0.767885976
## campaign        0.100490892 -0.007934948
-0.324028903 -0.575546022
## pdays           0.227536614 -0.628711981
0.252674001 -0.006719777
## previous       -0.305815059  0.474453454
-0.281754824 -0.021267326
## emp.var.rate    0.488002497  0.163001272
-0.091015114  0.044439336
## cons.price.idx  0.366097505  0.279060437
-0.276172371  0.073400593
## cons.conf.idx   0.101572714  0.427668539
0.510937020 -0.070490333
## euribor3m       0.490377105  0.148132110
-0.002732445  0.036446035
## nr.employed     0.470094939 -0.013534619
-0.029958110  0.027276466
##                         PC5          PC6          PC7
PC8
```

```
## age               0.44501766 -0.519053816  0.03130209
-0.017883104
## duration          0.59089472  0.222453386  0.03759640
0.036557378
## campaign          0.61975410  0.411271670  0.00457756
0.015618439
## pdays             0.05446567  0.017271037 -0.22220217
0.660616627
## previous         -0.03416913 -0.146373752  0.19252528
0.735882396
## emp.var.rate     -0.03068934 -0.075546254  0.07039768
0.047342403
## cons.price.idx  0.04059256 -0.249851072 -0.73172135
0.003923396
## cons.conf.idx  -0.23898992  0.647573823 -0.17299928
0.120583312
## euribor3m        -0.06312538  0.004006082  0.21662283
0.052635324
## nr.employed      -0.02971432 -0.052239619  0.54214369
0.024394248
##                          PC9          PC10
## age               1.877379e-03  0.0013597361
## duration         -1.291328e-03  0.0013824218
## campaign          1.144203e-05 -0.0092865724
## pdays             2.347902e-03  0.0007657793
## previous         -1.826083e-02  0.0042240094
## emp.var.rate      7.938804e-01  0.2844876703
## cons.price.idx -3.114171e-01  0.0997677428
## cons.conf.idx  -7.079644e-02  0.1216873967
## euribor3m        -6.342829e-02 -0.8237302095
## nr.employed      -5.132191e-01  0.4643979470
```

```
# Sample scores stored in bank_pca$x
head(bank_pca$x)
```

```
##            PC1       PC2       PC3           PC4
PC5          PC6
## [1,] 1.267965 0.8903042 1.4879965  0.005825065
```

```
0.1030323 -0.64157299
## [2,] 1.278857 0.8793100 1.5312801 -0.350188998
-0.1095116 -0.78747269
## [3,] 1.274291 0.4200501 0.3242263  0.364113463
-0.7880876  0.27473589
## [4,] 1.281232 0.4690169 0.4952702  0.069053460
-0.8309031  0.06096652
## [5,] 1.263429 0.9047474 1.4952566  0.142059472
0.2078658 -0.60210644
## [6,] 1.275841 0.6046332 0.8074897  0.086685008
-0.5102760 -0.14774523
##              PC7         PC8        PC9        PC10
## [1,] -0.3673217 0.022035364 0.02096648 -0.06246663
## [2,] -0.3805585 0.004527771 0.02170444 -0.06293331
## [3,] -0.4294668 0.049704934 0.01771796 -0.06513231
## [4,] -0.4313310 0.033982154 0.01863195 -0.06514076
## [5,] -0.3606516 0.028521187 0.02073738 -0.06222136
## [6,] -0.4094974 0.032028858 0.01929861 -0.06423778
```

```
# Identifying the scores by their survival status
banktyp_pca <- cbind(data.frame(bank$y),bank_pca$x)
head(banktyp_pca)
```

```
##   bank.y      PC1       PC2       PC3          PC4
PC5         PC6
## 1     no 1.267965 0.8903042 1.4879965  0.005825065
0.1030323 -0.64157299
## 2     no 1.278857 0.8793100 1.5312801 -0.350188998
-0.1095116 -0.78747269
## 3     no 1.274291 0.4200501 0.3242263  0.364113463
-0.7880876  0.27473589
## 4     no 1.281232 0.4690169 0.4952702  0.069053460
-0.8309031  0.06096652
## 5     no 1.263429 0.9047474 1.4952566  0.142059472
0.2078658 -0.60210644
## 6     no 1.275841 0.6046332 0.8074897  0.086685008
-0.5102760 -0.14774523
##           PC7         PC8        PC9        PC10
```

```
## 1 -0.3673217 0.022035364 0.02096648 -0.06246663
## 2 -0.3805585 0.004527771 0.02170444 -0.06293331
## 3 -0.4294668 0.049704934 0.01771796 -0.06513231
## 4 -0.4313310 0.033982154 0.01863195 -0.06514076
## 5 -0.3606516 0.028521187 0.02073738 -0.06222136
## 6 -0.4094974 0.032028858 0.01929861 -0.06423778
```

```
# Means of scores for all the PC's classified by
Cumstomer's response towards fixed deposit
tabmeansPC <- aggregate(banktyp_pca[,
2:11],by=list(y=bank$y),mean)
tabmeansPC
```

```
##     y        PC1         PC2          PC3        PC4
PC5
## 1  no  0.2383454 -0.08932705 -0.005245612 -0.1036727
-0.07368158
## 2 yes -1.8773812  0.70360454  0.041318235  0.8166011
0.58036947
##          PC6         PC7         PC8          PC9
PC10
## 1 -0.04175336  0.02044733  0.02312943  0.0007812426
0.0003684071
## 2  0.32887966 -0.16105800 -0.18218418 -0.0061536325
-0.0029018412
```

```
tabmeansPC <- tabmeansPC[rev(order(tabmeansPC$y)),]
tabmeansPC
```

```
##     y        PC1         PC2          PC3        PC4
PC5
## 2 yes -1.8773812  0.70360454  0.041318235  0.8166011
0.58036947
## 1  no  0.2383454 -0.08932705 -0.005245612 -0.1036727
-0.07368158
##          PC6         PC7         PC8          PC9
PC10
## 2  0.32887966 -0.16105800 -0.18218418 -0.0061536325
-0.0029018412
## 1 -0.04175336  0.02044733  0.02312943  0.0007812426
```

```
0.0003684071
```

```
tabfmeans <- t(tabmeansPC[,-1])
tabfmeans
```

```
##                2            1
## PC1  -1.877381240  0.2383454348
## PC2   0.703604537 -0.0893270508
## PC3   0.041318235 -0.0052456115
## PC4   0.816601100 -0.1036726798
## PC5   0.580369471 -0.0736815789
## PC6   0.328879662 -0.0417533554
## PC7  -0.161057997  0.0204473325
## PC8  -0.182184175  0.0231294346
## PC9  -0.006153632  0.0007812426
## PC10 -0.002901841  0.0003684071
```

```
colnames(tabfmeans) <- t(as.vector(tabmeansPC[1]))
tabfmeans
```

```
##              yes            no
## PC1  -1.877381240  0.2383454348
## PC2   0.703604537 -0.0893270508
## PC3   0.041318235 -0.0052456115
## PC4   0.816601100 -0.1036726798
## PC5   0.580369471 -0.0736815789
## PC6   0.328879662 -0.0417533554
## PC7  -0.161057997  0.0204473325
## PC8  -0.182184175  0.0231294346
## PC9  -0.006153632  0.0007812426
## PC10 -0.002901841  0.0003684071
```

```
# Standard deviations of scores for all the PC's
classified by Bank$y
tabsdsPC <- aggregate(banktyp_pca[,
2:11],by=list(y=bank$y),sd)
tabfsds <- t(tabsdsPC[,-1])
colnames(tabfsds) <- t(as.vector(tabsdsPC[1]))
tabfsds
```

```
##             no       yes
## PC1  1.80836703 2.2022105
```

```
## PC2  0.92144630 2.1949059
## PC3  0.96048176 1.5159219
## PC4  0.92523896 1.3526315
## PC5  0.89843006 1.2301639
## PC6  0.86386338 1.2136866
## PC7  0.59178344 0.9930270
## PC8  0.54586330 1.0196774
## PC9  0.14816401 0.2190531
## PC10 0.09892813 0.1305217
```

```
#t test on all the Principal Components
t.test(PC1~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC1 by bank$y
## t = 62.809, df = 5462.2, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  2.049691 2.181763
## sample estimates:
##  mean in group no mean in group yes
##         0.2383454        -1.8773812
```

```
t.test(PC2~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC2 by bank$y
## t = -24.337, df = 4848.6, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.8568048 -0.7290584
## sample estimates:
##  mean in group no mean in group yes
##       -0.08932705        0.70360454
```

```
t.test(PC3~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC3 by bank$y
## t = -2.041, df = 5122.2, p-value = 0.0413
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.091290135 -0.001837558
## sample estimates:
##  mean in group no mean in group yes
##      -0.005245612       0.041318235
```

```
t.test(PC4~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC4 by bank$y
## t = -45.026, df = 5204.2, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.9603420 -0.8802056
## sample estimates:
##  mean in group no mean in group yes
##        -0.1036727         0.8166011
```

```
t.test(PC5~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC5 by bank$y
## t = -35.049, df = 5285.5, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.6906341 -0.6174680
```

```
## sample estimates:
##  mean in group no mean in group yes
##       -0.07368158        0.58036947
t.test(PC6~bank$y,data=banktyp_pca)
##
##  Welch Two Sample t-test
##
## data:  PC6 by bank$y
## t = -20.163, df = 5252.2, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.4066686 -0.3345974
## sample estimates:
##  mean in group no mean in group yes
##       -0.04175336        0.32887966
t.test(PC7~bank$y,data=banktyp_pca)
##
##  Welch Two Sample t-test
##
## data:  PC7 by bank$y
## t = 12.179, df = 5065.4, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  0.1522887 0.2107220
## sample estimates:
##  mean in group no mean in group yes
##        0.02044733       -0.16105800
t.test(PC8~bank$y,data=banktyp_pca)
##
##  Welch Two Sample t-test
##
## data:  PC8 by bank$y
## t = 13.473, df = 4981.9, p-value < 2.2e-16
## alternative hypothesis: true difference in means is
```

```
not equal to 0
## 95 percent confidence interval:
##  0.1754379 0.2351893
## sample estimates:
##  mean in group no mean in group yes
##        0.02312943       -0.18218418
```

```
t.test(PC9~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC9 by bank$y
## t = 2.0965, df = 5191.3, p-value = 0.03609
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  0.0004500319 0.0134197183
## sample estimates:
##  mean in group no mean in group yes
##      0.0007812426     -0.0061536325
```

```
t.test(PC10~bank$y,data=banktyp_pca)
```

```
##
##  Welch Two Sample t-test
##
## data:  PC10 by bank$y
## t = 1.6477, df = 5336.8, p-value = 0.09948
## alternative hypothesis: true difference in means is
not equal to 0
## 95 percent confidence interval:
##  -0.0006207109  0.0071612075
## sample estimates:
##  mean in group no mean in group yes
##      0.0003684071     -0.0029018412
```

```
# F ratio tests
var.test(PC1~bank$y,data=banktyp_pca)
```

```
##
##  F test to compare two variances
```

```
##
## data:  PC1 by bank$y
## F = 0.6743, num df = 36547, denom df = 4639, p-value
< 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.6455535 0.7038181
## sample estimates:
## ratio of variances
##          0.6743036
```

```
var.test(PC2~bank$y,data=banktyp_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC2 by bank$y
## F = 0.17624, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.1687272 0.1839557
## sample estimates:
## ratio of variances
##          0.1762415
```

```
var.test(PC3~bank$y,data=banktyp_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC3 by bank$y
## F = 0.40144, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.3843274 0.4190149
```

```
## sample estimates:
## ratio of variances
##          0.4014436
var.test(PC4~bank$y,data=banktyp_pca)
##
##  F test to compare two variances
##
## data:  PC4 by bank$y
## F = 0.4679, num df = 36547, denom df = 4639, p-value
< 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.4479459 0.4883753
## sample estimates:
## ratio of variances
##          0.4678954
var.test(PC5~bank$y,data=banktyp_pca)
##
##  F test to compare two variances
##
## data:  PC5 by bank$y
## F = 0.53339, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.5106453 0.5567337
## sample estimates:
## ratio of variances
##          0.5333872
var.test(PC6~bank$y,data=banktyp_pca)
##
##  F test to compare two variances
##
## data:  PC6 by bank$y
```

```
## F = 0.50661, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.4850134 0.5287884
## sample estimates:
## ratio of variances
##          0.5066138
```

```
var.test(PC7~bank$y,data=banktyp_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC7 by bank$y
## F = 0.35514, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.3400010 0.3706879
## sample estimates:
## ratio of variances
##          0.3551432
```

```
var.test(PC8~bank$y,data=banktyp_pca)
```

```
##
##  F test to compare two variances
##
## data:  PC8 by bank$y
## F = 0.28658, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.2743588 0.2991211
## sample estimates:
## ratio of variances
```

```
##          0.2865776
var.test(PC9~bank$y,data=banktyp_pca)
##
##  F test to compare two variances
##
## data:  PC9 by bank$y
## F = 0.4575, num df = 36547, denom df = 4639, p-value
< 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.4379890 0.4775198
## sample estimates:
## ratio of variances
##          0.4574952
var.test(PC10~bank$y,data=banktyp_pca)
##
##  F test to compare two variances
##
## data:  PC10 by bank$y
## F = 0.57448, num df = 36547, denom df = 4639, p-
value < 2.2e-16
## alternative hypothesis: true ratio of variances is
not equal to 1
## 95 percent confidence interval:
##  0.5499854 0.5996244
## sample estimates:
## ratio of variances
##          0.5744793
# Levene's tests (one-sided)
library(car)
## Loading required package: carData
(LTPC1 <- leveneTest(PC1~bank$y,data=banktyp_pca))
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
```

```
## group     1  248.99 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(LTPC1 <- leveneTest(PC1~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1  248.99 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC1_1sided <- LTPC1[[3]][1]/2)
```

```
## [1] 3.145583e-56
```

```
(LTPC2 <- leveneTest(PC2~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1  4799.7 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC2_1sided=LTPC2[[3]][1]/2)
```

```
## [1] 0
```

```
(LTPC3 <- leveneTest(PC3~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1  1515.2 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC3_1sided=LTPC3[[3]][1]/2)
## [1] 0
(LTPC4 <- leveneTest(PC4~bank$y,data=banktyp_pca))
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1  1363.3 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
(p_PC4_1sided=LTPC4[[3]][1]/2)
## [1] 6.313288e-294
(LTPC5 <- leveneTest(PC5~bank$y,data=banktyp_pca))
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1  917.34 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
(p_PC5_1sided=LTPC5[[3]][1]/2)
## [1] 1.29368e-199
(LTPC6 <- leveneTest(PC6~bank$y,data=banktyp_pca))
## Levene's Test for Homogeneity of Variance (center =
median)
##          Df F value    Pr(>F)
## group     1   844.1 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
(p_PC6_1sided=LTPC6[[3]][1]/2)
## [1] 5.025655e-184
(LTPC7 <- leveneTest(PC7~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##           Df F value    Pr(>F)
## group      1  1507.7 < 2.2e-16 ***
##        41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC7_1sided=LTPC7[[3]][1]/2)
```

```
## [1] 0
```

```
(LTPC8 <- leveneTest(PC8~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##           Df F value    Pr(>F)
## group      1  2031.5 < 2.2e-16 ***
##        41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC8_1sided=LTPC8[[3]][1]/2)
```

```
## [1] 0
```

```
(LTPC9 <- leveneTest(PC9~bank$y,data=banktyp_pca))
```

```
## Levene's Test for Homogeneity of Variance (center =
median)
##           Df F value    Pr(>F)
## group      1  1123.2 < 2.2e-16 ***
##        41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

```
(p_PC9_1sided=LTPC9[[3]][1]/2)
```

```
## [1] 2.814464e-243
```

```
(LTPC10 <- leveneTest(PC10~bank$y,data=banktyp_pca))
```

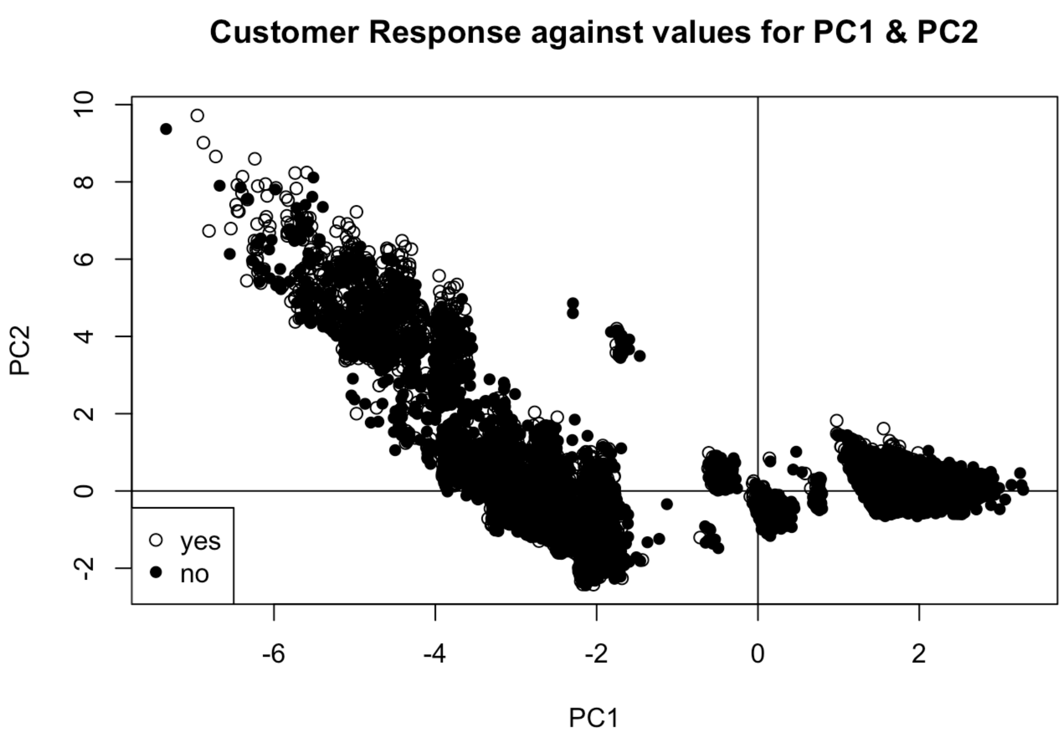
```
## Levene's Test for Homogeneity of Variance (center =
median)
##           Df F value    Pr(>F)
```

```
## group      1   343.1 < 2.2e-16 ***
##       41186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
0.1 ' ' 1
```

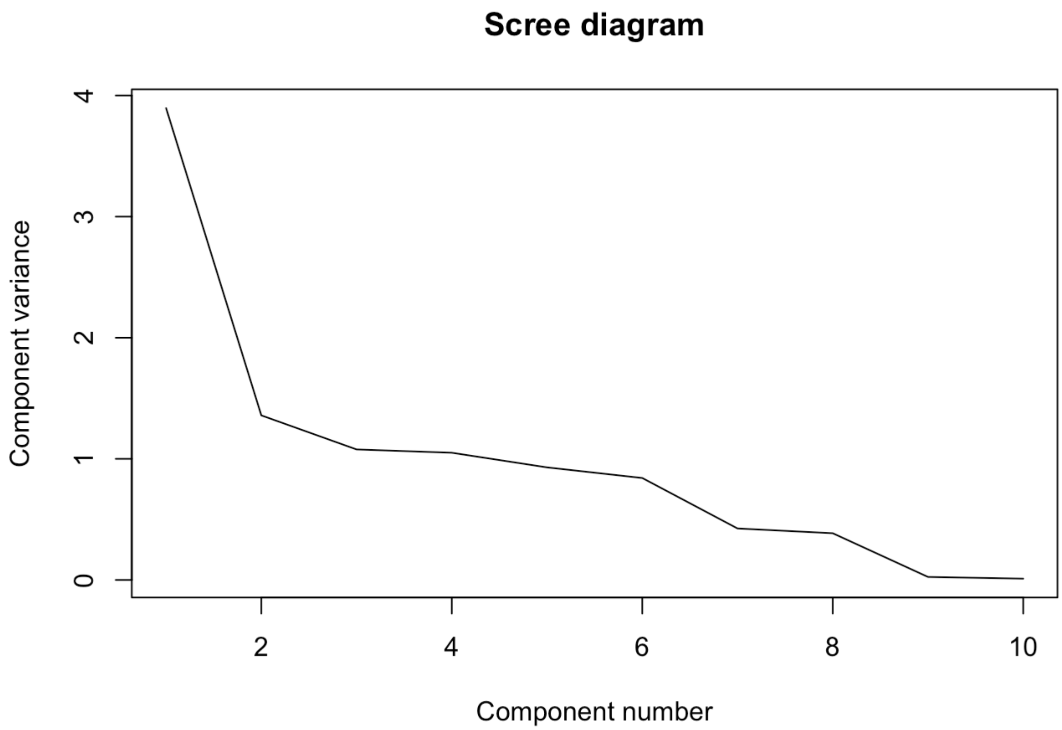
```
(p_PC10_1sided=LTPC10[[3]][1]/2)
```

```
## [1] 1.378121e-76
```

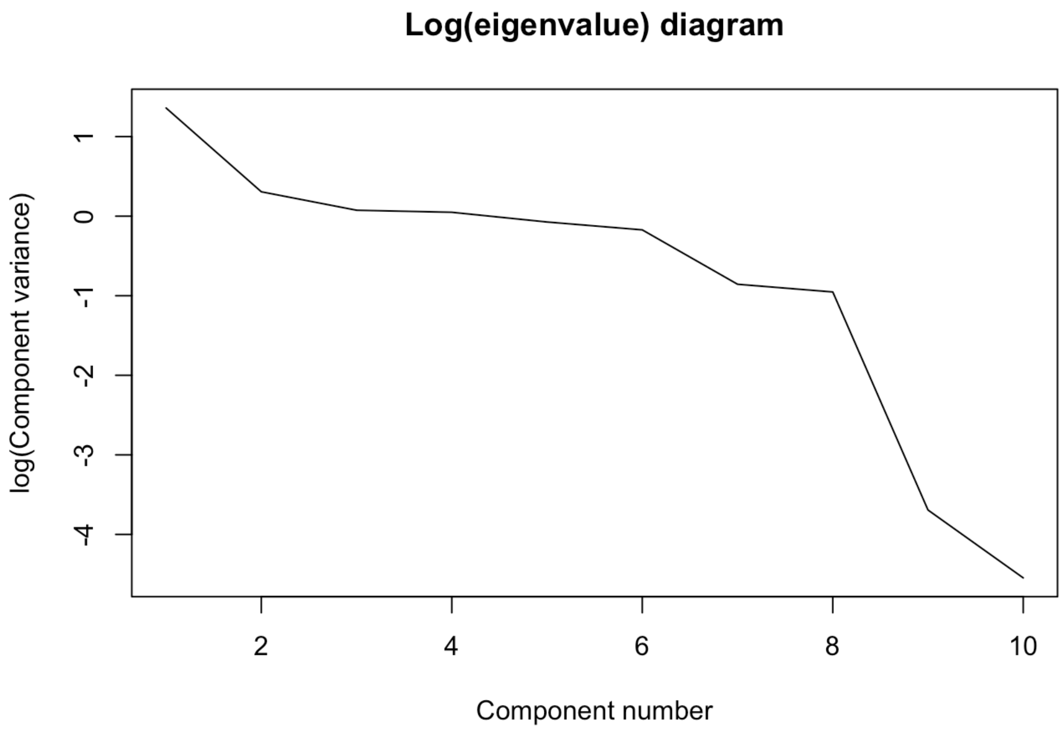
```
# Plotting the scores for the first and second
components
plot(banktyp_pca$PC1,
banktyp_pca$PC2,pch=ifelse(banktyp_pca$bank.y == "yes",
1,16),xlab="PC1", ylab="PC2", main="Customer Response
against values for PC1 & PC2")
abline(h=0)
abline(v=0)
legend("bottomleft", legend=c("yes","no"), pch=c(1,16))
```




```
plot(eigen_bank, xlab = "Component number", ylab =
"Component variance", type = "l", main = "Scree
diagram")
```




```
#where bending - chossing pC componeet or >.7
#6
plot(log(eigen_bank), xlab = "Component number",ylab =
"log(Component variance)", type="l",main =
"Log(eigenvalue) diagram")
```




```
#9 are good
print(summary(bank_pca))
## Importance of components:
##                           PC1    PC2    PC3    PC4
PC5     PC6     PC7
## Standard deviation     1.9737 1.1657 1.0381 1.0249
0.96408 0.91751 0.65201
## Proportion of Variance 0.3896 0.1359 0.1078 0.1050
0.09295 0.08418 0.04251
## Cumulative Proportion  0.3896 0.5254 0.6332 0.7382
0.83118 0.91537 0.95788
##                            PC8     PC9    PC10
## Standard deviation     0.62106 0.15776 0.10298
## Proportion of Variance 0.03857 0.00249 0.00106
## Cumulative Proportion  0.99645 0.99894 1.00000
diag(cov(bank_pca$x))
##        PC1        PC2        PC3        PC4
PC5        PC6
## 3.89549575 1.35888318 1.07764506 1.05036054
```

```
0.92945344 0.84183259
##        PC7        PC8        PC9       PC10
## 0.42511495 0.38572154 0.02488887 0.01060409
```

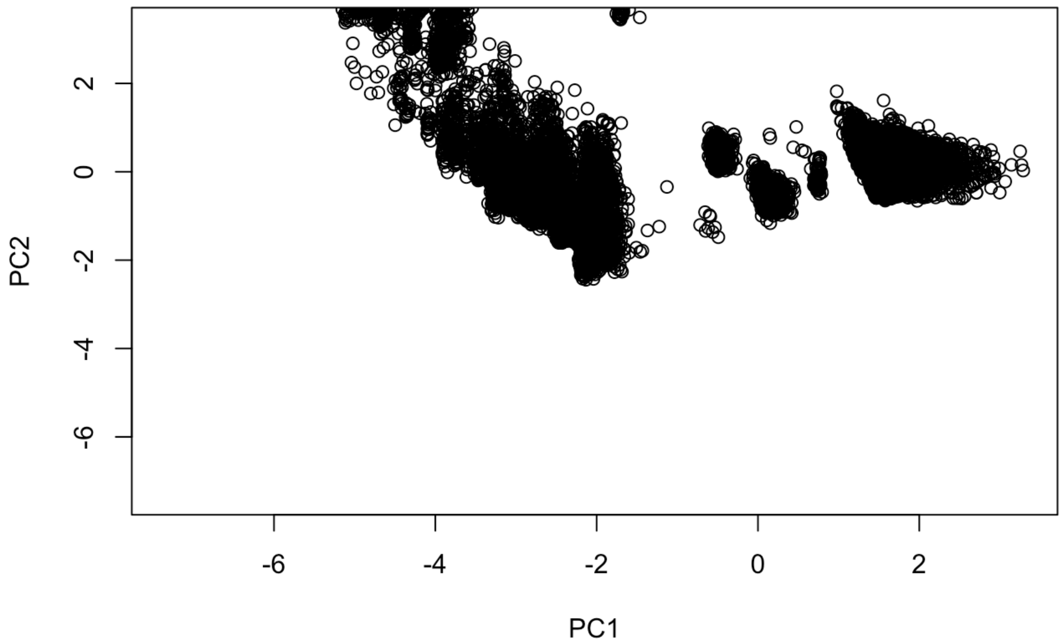
```
xlim <- range(bank_pca$x[,1])
head(bank_pca$x[,1])
```

```
## [1] 1.267965 1.278857 1.274291 1.281232 1.263429
1.275841
```

```
head(bank_pca$x)
```

```
##           PC1       PC2       PC3          PC4
PC5         PC6
## [1,] 1.267965 0.8903042 1.4879965  0.005825065
0.1030323 -0.64157299
## [2,] 1.278857 0.8793100 1.5312801 -0.350188998
-0.1095116 -0.78747269
## [3,] 1.274291 0.4200501 0.3242263  0.364113463
-0.7880876  0.27473589
## [4,] 1.281232 0.4690169 0.4952702  0.069053460
-0.8309031  0.06096652
## [5,] 1.263429 0.9047474 1.4952566  0.142059472
0.2078658 -0.60210644
## [6,] 1.275841 0.6046332 0.8074897  0.086685008
-0.5102760 -0.14774523
##             PC7         PC8        PC9        PC10
## [1,] -0.3673217 0.022035364 0.02096648 -0.06246663
## [2,] -0.3805585 0.004527771 0.02170444 -0.06293331
## [3,] -0.4294668 0.049704934 0.01771796 -0.06513231
## [4,] -0.4313310 0.033982154 0.01863195 -0.06514076
## [5,] -0.3606516 0.028521187 0.02073738 -0.06222136
## [6,] -0.4094974 0.032028858 0.01929861 -0.06423778
```

```
plot(bank_pca$x,xlim=xlim,ylim=xlim)
```




```
bank_pca$rotation[,1]
```

```
##             age        duration       campaign
pdays       previous
##   -0.001577131   -0.025564414    0.100490892
0.227536614   -0.305815059
##   emp.var.rate cons.price.idx  cons.conf.idx
euribor3m    nr.employed
##    0.488002497    0.366097505    0.101572714
0.490377105    0.470094939
```

```
bank_pca$rotation
```

```
##                           PC1          PC2
PC3          PC4
## age              -0.001577131  0.251900655
0.635282811 -0.253370761
## duration         -0.025564414  0.081409042
0.040921453  0.767885976
## campaign          0.100490892 -0.007934948
-0.324028903 -0.575546022
## pdays             0.227536614 -0.628711981
```

```
0.252674001 -0.006719777
## previous       -0.305815059  0.474453454
-0.281754824 -0.021267326
## emp.var.rate    0.488002497  0.163001272
-0.091015114  0.044439336
## cons.price.idx  0.366097505  0.279060437
-0.276172371  0.073400593
## cons.conf.idx   0.101572714  0.427668539
0.510937020 -0.070490333
## euribor3m       0.490377105  0.148132110
-0.002732445  0.036446035
## nr.employed     0.470094939 -0.013534619
-0.029958110  0.027276466
##                        PC5          PC6         PC7
PC8
## age             0.44501766 -0.519053816  0.03130209
-0.017883104
## duration        0.59089472  0.222453386  0.03759640
0.036557378
## campaign        0.61975410  0.411271670  0.00457756
0.015618439
## pdays           0.05446567  0.017271037 -0.22220217
0.660616627
## previous       -0.03416913 -0.146373752  0.19252528
0.735882396
## emp.var.rate   -0.03068934 -0.075546254  0.07039768
0.047342403
## cons.price.idx  0.04059256 -0.249851072 -0.73172135
0.003923396
## cons.conf.idx  -0.23898992  0.647573823 -0.17299928
0.120583312
## euribor3m      -0.06312538  0.004006082  0.21662283
0.052635324
## nr.employed    -0.02971432 -0.052239619  0.54214369
0.024394248
##                          PC9          PC10
```

```
## age              1.877379e-03  0.0013597361
## duration        -1.291328e-03  0.0013824218
## campaign         1.144203e-05 -0.0092865724
## pdays            2.347902e-03  0.0007657793
## previous        -1.826083e-02  0.0042240094
## emp.var.rate     7.938804e-01  0.2844876703
## cons.price.idx -3.114171e-01  0.0997677428
## cons.conf.idx  -7.079644e-02  0.1216873967
## euribor3m      -6.342829e-02 -0.8237302095
## nr.employed    -5.132191e-01  0.4643979470
```

```
#get the original value of the data based on PCA
#center <- bank_pca$center
#scale <- bank_pca$scale
#new_bank <- as.matrix(bank_pca_data)
#head(new_bank)
#drop(scale(new_bank,center=center, scale=scale)
%*%bank_pca$rotation[,1])
#drop(new_bank%*%bank_pca$rotation[,1])
#predict(bank_pca)[,1]
#scale it back up
#The aboved two gives us the same thing. predict is a
good function to know.
```