Bonnie_Daniel_Assignment1

Problem 1

Do certain kinds of voting equimentment lead to greater percentages of undercount?

Attaching libraries:

```
library(mosaic)
library(foreach)
```

Reading in the file:

```
georgiavotes = read.csv('../HW1/georgia2000.csv', header = TRUE)
head(georgiavotes)
```

```
##     county ballots votes   equip poor urban atlanta perAA gore bush
## 1  APPLING    6617  6099   LEVER    1     0       0 0.182 2093 3940
## 2 ATKINSON    2149  2071   LEVER    1     0       0 0.230  821 1228
## 3    BACON    3347  2995   LEVER    1     0       0 0.131  956 2010
## 4    BAKER    1607  1519 OPTICAL    1     0       0 0.476  893  615
## 5  BALDWIN   12785 12126   LEVER    0     0       0 0.359 5893 6041
## 6    BANKS    4773  4533   LEVER    0     0       0 0.024 1220 3202
```

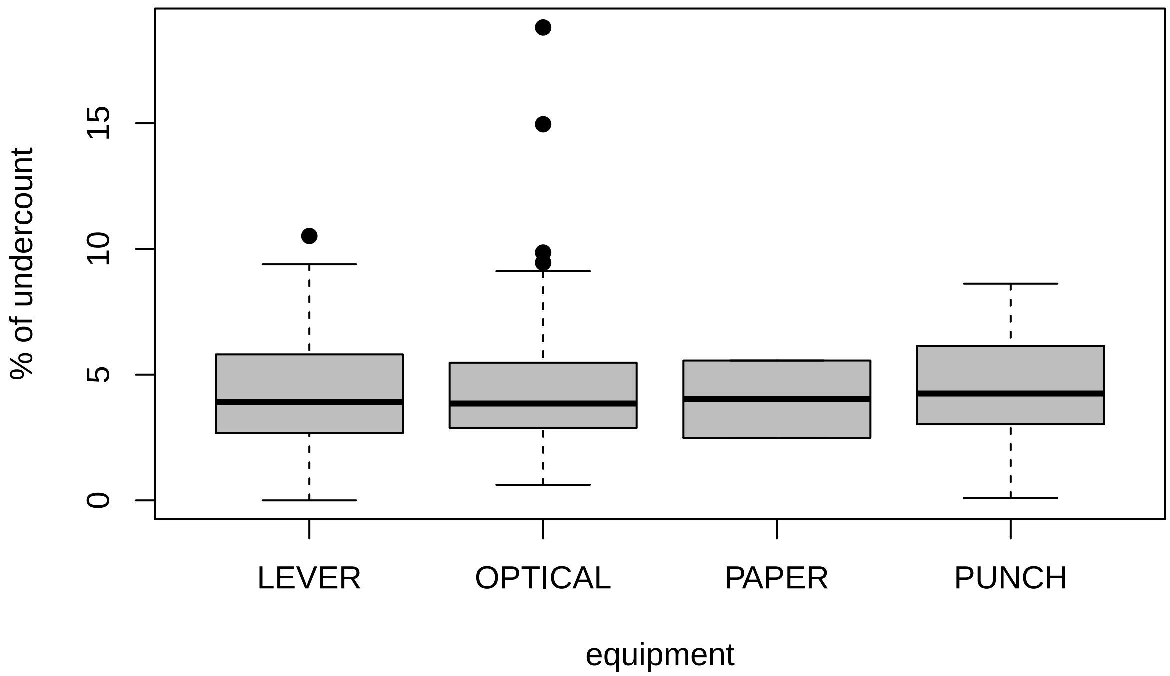
```
attach(georgiavotes)
```

We have a column recording the ballots and a column recording the votes. We need a new column called votecount to record the undercount percentage for each county.

```
votecount = ((ballots-votes)/ballots)*100
georgiavotes = cbind(georgiavotes, 'votecount')
```

By plotting votecount against the type of equipment used to vote, we can see if there are any major differences among types of equiment.

```
plot(equip, votecount, pch = 19, col = 'grey',
  xlab = 'equipment',
  ylab = '% of undercount')
```

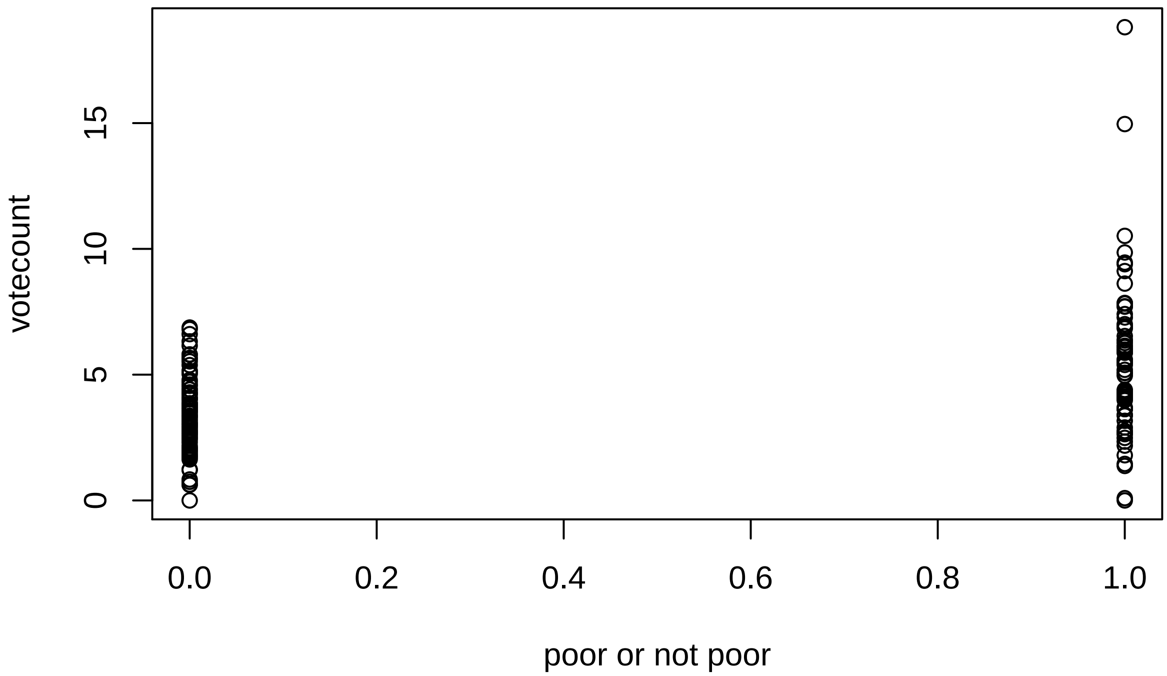


From the boxplot, it does not look like there is a significant difference between each kind of voting equipment. The median for each of the types of equipment are about the same at 4% and the range between the quartiles for each is about the same. The main difference are the outliers for the optical and lever plots, where there are 4 outlying counties that use optical voting machines and 1 outlying county that uses lever voting machines.

Does this link between voting machines and % of undercount disparately impact poor and minority counties?

First, we need to see if there is a link between poor counties and % of undercount, then we need to investigate if there is a link between percentage of African Americans within a county and the % of undercount.

```
plot(poor, votecount, xlab = 'poor or not poor', ylab = 'votecount')
```

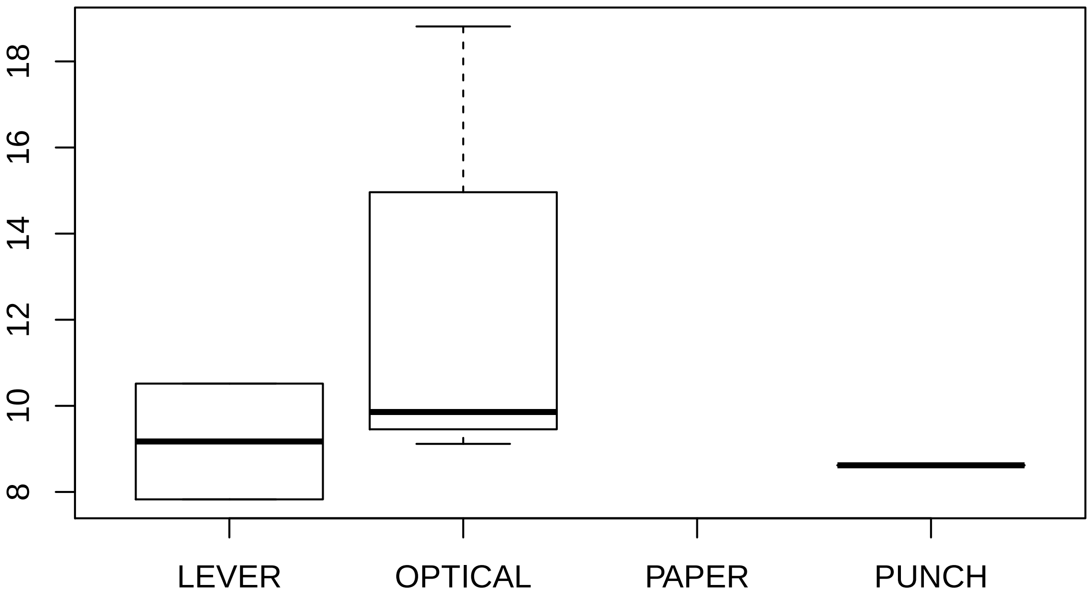


From this plot, it is obvious that poor counties have a higher variance in votecount than counties that are not poor. Counties that are not considered poor have consistently lower undercount percentages. To investigate whether this is also linked to voting machine types, identifying the counties that are poor and have a high undercount percentage and then linking these to the voting machine type could be helpful.

```
outliers = c(1,3,9,19,120,133,140,153)
georgiavotes[outliers,]
```

```
##       county ballots votes   equip poor urban atlanta perAA gore bush
## 1    APPLING    6617  6099   LEVER    1     0       0 0.182 2093 3940
## 3      BACON    3347  2995   LEVER    1     0       0 0.131  956 2010
## 9   BEN.HILL    5741  4661 OPTICAL    1     0       0 0.282 2234 2381
## 19   CALHOUN    2065  1887   PUNCH    1     0       0 0.562 1107  768
## 120 RANDOLPH    3021  2569 OPTICAL    1     0       0 0.527 1381 1174
## 133   TAYLOR    3084  2780 OPTICAL    1     0       0 0.402 1340 1412
## 140 TREUTLEN    2168  1963 OPTICAL    1     0       0 0.293  879 1062
## 153  WHEELER    1733  1575 OPTICAL    1     0       0 0.254  752  813
##     "votecount"
## 1     votecount
## 3     votecount
## 9     votecount
## 19    votecount
## 120   votecount
## 133   votecount
## 140   votecount
## 153   votecount
```

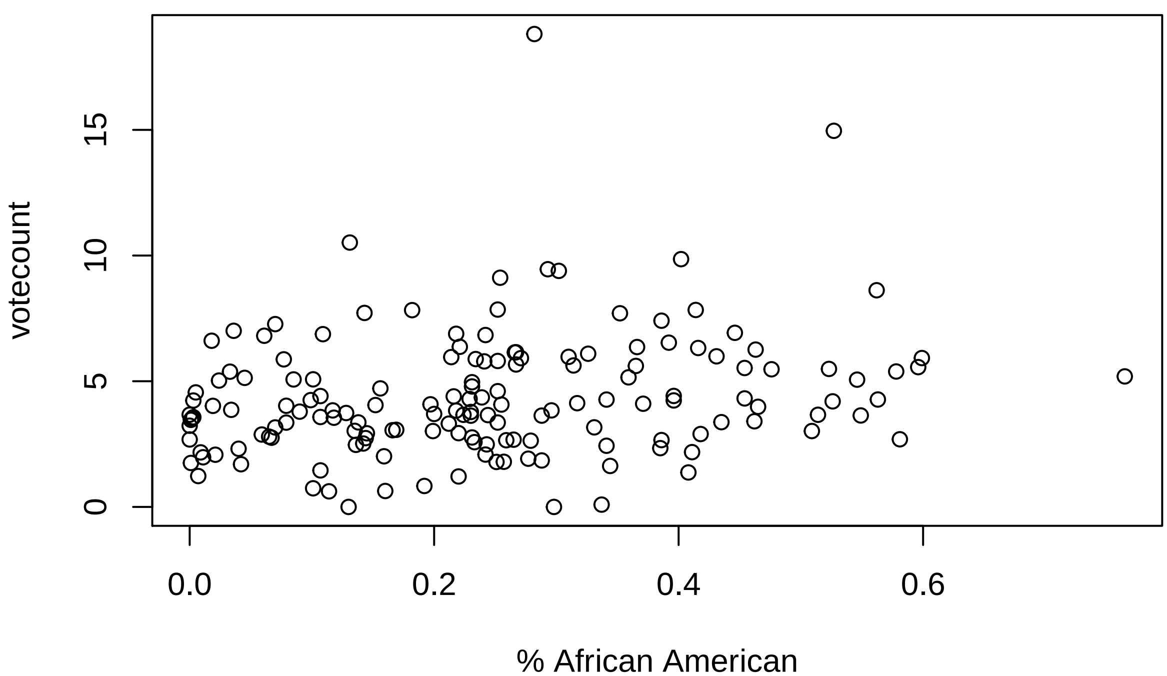
```r
plot(equip[outliers], votecount[outliers])
```



The outliers (or counties that have a higher votecount score than any not poor county) are Appling, Bacon, Ben Hill, Calhoun, Randolph, Taylor, Treutlen And Wheeler counties. When just these counties are plotted for lever vs. votecount, only the punch, lever and optical machine types are accounted for. The optical machines have the highest median and the widest spread in terms of undercount percentage. From here, I would conclude that optical machines, poor counties, and a high undercount percentage are linked.

Next, we investigate if a similar pattern appears when we use the perAA variable in lieu of the poor variable.

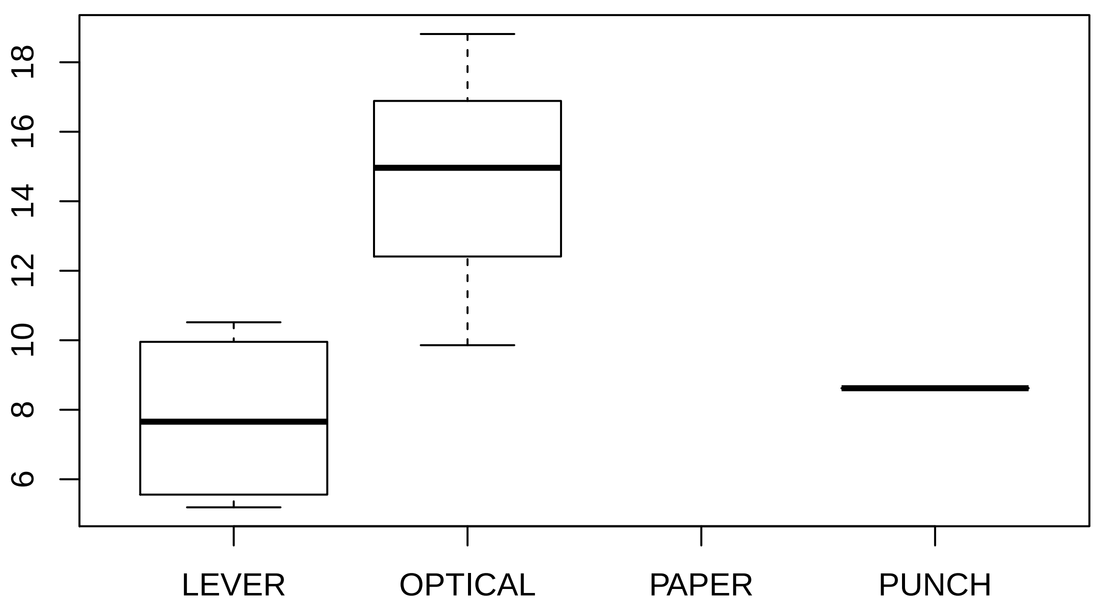
```r
plot(perAA, votecount, xlab = '% African American', ylab = 'votecount')
```



```r
outlierspersAA = c(3, 9, 19, 70, 120, 128, 133, 134)
georgiavotes[outlierspersAA,]
```

```
##       county ballots votes   equip poor urban atlanta perAA gore bush
## 3      BACON    3347  2995   LEVER    1     0       0 0.131  956 2010
## 9   BEN.HILL    5741  4661 OPTICAL    1     0       0 0.282 2234 2381
## 19   CALHOUN    2065  1887   PUNCH    1     0       0 0.562 1107  768
## 70   HANCOCK    3255  3086   LEVER    1     0       0 0.765 2414  662
## 120 RANDOLPH    3021  2569 OPTICAL    1     0       0 0.527 1381 1174
## 128  STEWART    2077  1954   LEVER    1     0       0 0.599 1267  675
## 133   TAYLOR    3084  2780 OPTICAL    1     0       0 0.402 1340 1412
## 134  TELFAIR    3855  3493   LEVER    1     0       0 0.302 1777 1693
##     "votecount"
## 3     votecount
## 9     votecount
## 19    votecount
## 70    votecount
## 120   votecount
## 128   votecount
## 133   votecount
## 134   votecount
```

```r
plot(equip[outlierspersAA], votecount[outlierspersAA])
```



The outliers for the percent of African Americans compared to the percent of undercount were similar to the counties above; the two share Bacon, Ben Hill, Calhoun, Randolph, and Taylor counties. Several other counties were outliers here but not above: Hancock, Stewart and Telfair counties. When plotting only the outliers on the voting equipment against percent of undercount, we find a stunningly similar graph to the poor county outliers. None of the outliers used paper ballots, and the counties that had the highest rates of undercounting used optical machines.

Therefore, it appears that the relationship between the type of voting equipment and percent of undercounting is very relevant in poor and minority counties.

Problem 2

What are the different ways to invest in five asset classes? Which one is the riskiest and which one is the safest?

Below we read in a library and the assets SPY, TLT, LQD, EEM and VNQ for the past five years. Then we calculate the returns from the prices for each asset.

```r
library(fImport)
```

```
## Loading required package: timeDate
## Loading required package: timeSeries
```

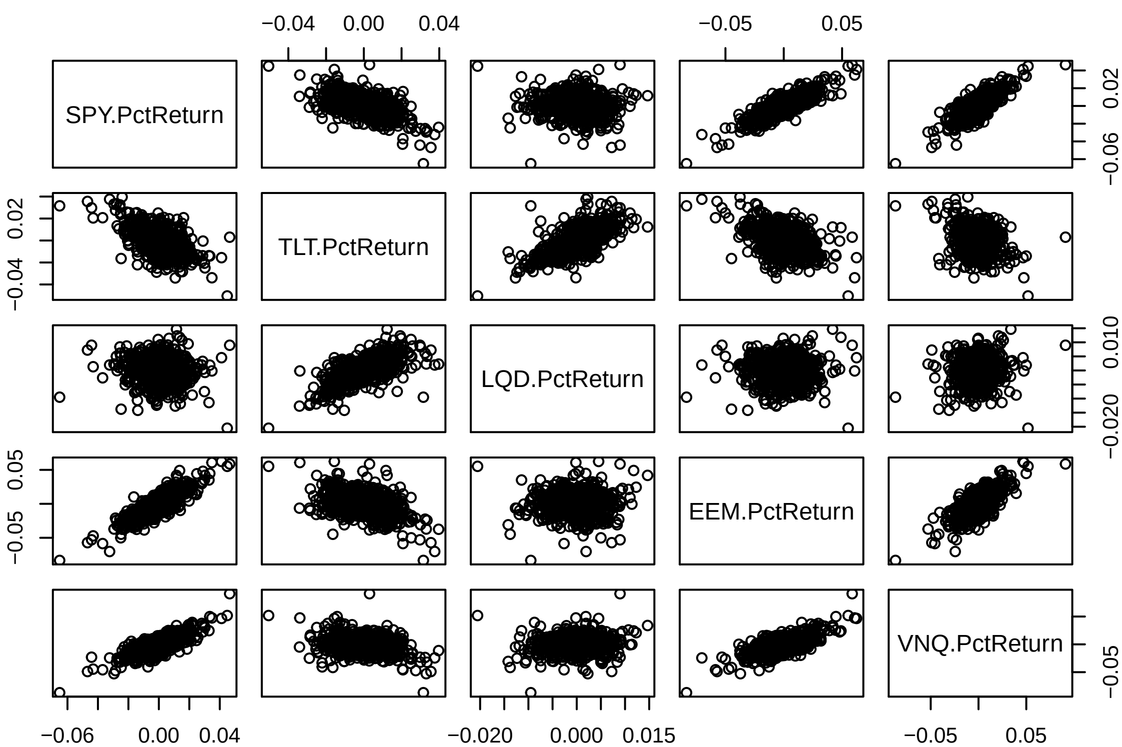
```r
assets = c("SPY","TLT","LQD","EEM","VNQ")
prices = yahooSeries(assets, from = '2010-07-30', to = '2015-07-30')
head(prices)
```

```
## GMT
##            SPY.Open SPY.High SPY.Low SPY.Close SPY.Volume SPY.Adj.Close
## 2010-07-30   109.17   110.86  108.98    110.27  220070600      99.58393
## 2010-08-02   111.99   112.94  111.54    112.76  188263200     101.83264
## 2010-08-03   112.48   112.77  111.85    112.22  146657300     101.34497
## 2010-08-04   112.53   113.11  112.16    112.97  158171700     102.02229
## 2010-08-05   112.25   112.91  112.08    112.85  140473800     101.91391
## 2010-08-06   111.74   112.57  110.92    112.39  239728300     101.49849
##            TLT.Open TLT.High TLT.Low TLT.Close TLT.Volume TLT.Adj.Close
## 2010-07-30   100.20   100.61   99.85    100.48    7683200      85.81440
## 2010-08-02    99.24    99.33   98.75     98.75    5769200      84.60973
## 2010-08-03    99.20    99.66   98.93     99.32    4363500      85.09811
## 2010-08-04    99.50    99.51   98.56     98.56    3820400      84.44693
## 2010-08-05    99.34    99.49   98.84     99.02    3704200      84.84106
## 2010-08-06    99.79   100.21   99.49    100.10    6042400      85.76641
##            LQD.Open LQD.High LQD.Low LQD.Close LQD.Volume LQD.Adj.Close
## 2010-07-30   110.03   110.42  110.03    110.30     796300      90.72349
## 2010-08-02   109.91   109.95  109.56    109.63     764100      90.53107
## 2010-08-03   109.90   110.04  109.70    109.90    1060700      90.75404
## 2010-08-04   109.83   109.95  109.55    109.56     859900      90.47327
## 2010-08-05   109.69   109.89  109.59    109.76    1093400      90.63843
## 2010-08-06   110.19   110.48  110.06    110.39     685700      91.15867
##            EEM.Open EEM.High EEM.Low EEM.Close EEM.Volume EEM.Adj.Close
## 2010-07-30    40.89    41.53   40.76     41.40   54277200      37.54588
## 2010-08-02    42.18    42.59   42.07     42.47   69623700      38.51627
## 2010-08-03    42.14    42.43   41.93     42.27   60207900      38.33489
## 2010-08-04    42.28    42.43   42.00     42.33   55875600      38.38930
## 2010-08-05    42.02    42.20   41.87     42.14   43650600      38.21699
## 2010-08-06    41.86    42.19   41.60     42.08   65731600      38.16258
##            VNQ.Open VNQ.High VNQ.Low VNQ.Close VNQ.Volume VNQ.Adj.Close
## 2010-07-30    50.08    51.21   49.95     50.95    2746300      42.18010
## 2010-08-02    51.78    52.81   51.62     52.66    3018300      43.59576
## 2010-08-03    52.53    52.57   51.78     52.15    1955500      43.17355
## 2010-08-04    52.39    52.54   51.90     52.52    2041300      43.47986
## 2010-08-05    52.24    52.50   51.75     51.86    1847300      42.93346
## 2010-08-06    51.31    51.78   50.76     51.62    1836100      42.73477
```

```r
YahooPricesToReturns = function(series) {
    mycols = grep('Adj.Close', colnames(series))
    closingprice = series[,mycols]
    N = nrow(closingprice)
    percentreturn = as.data.frame(closingprice[2:N,]) / as.data.frame(closingprice[1:(N-1),]) - 1
    mynames = strsplit(colnames(percentreturn), '.', fixed=TRUE)
    mynames = lapply(mynames, function(x) return(paste0(x[1], ".PctReturn")))
    colnames(percentreturn) = mynames
    as.matrix(na.omit(percentreturn))
}
returns = YahooPricesToReturns(prices)
```

To understand the risk/return properties of each of the asset classes, we can plot the pairs of returns against one another, and then find the beta coefficient of each asset class in comparison to SPY.

```r
pairs(returns)
```




```r
lm_TLT = lm(returns[,2] ~ returns[,1])
lm_LQD = lm(returns[,3] ~ returns[,1])
lm_EEM = lm(returns[,4] ~ returns[,1])
lm_VNQ = lm(returns[,5] ~ returns[,1])

# The estimated beta for each asset class based on daily returns
coef(lm_TLT); coef(lm_LQD); coef(lm_EEM); coef(lm_VNQ)
```

```
##   (Intercept)  returns[, 1]
##  0.0006852609 -0.5652413911
```

```
##   (Intercept)  returns[, 1]
##  0.0002272818 -0.0460092719

##   (Intercept)  returns[, 1]
## -0.0007113474  1.2310255668

##   (Intercept)  returns[, 1]
## -0.0000526187  0.9558821694
```

This plot shows the association between each of the classes and the estimated beta for each asset class. From both of these, we can see that the TLT and LQD assets are negatively associated with SPY (TLT dramatically more so than LQD) and the EEM and VNQ assets are positively associated with SPY. This indicates that TLT and LQD are relatively safe investments while EEM and VNQ are as or more risky than the market.

A safe portfolio would include the SPY asset class, the TLT asset class and the LQD asset class, as all of these asset classes are relatively safe. A more aggresive portfolio might include one of the safer asset classes, but would definitely include the EEM and VNQ asset classes.

Even distribution portfolio (20% of the initial investment in each of the assets):

```r
library(foreach)
library(mosaic)
```

```
## Loading required package: car
## Loading required package: dplyr
##
## Attaching package: 'dplyr'
##
## The following objects are masked from 'package:timeSeries':
##
##     filter, lag
##
## The following objects are masked from 'package:stats':
##
##     filter, lag
##
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
##
## Loading required package: lattice
## Loading required package: ggplot2
## Loading required package: mosaicData
##
## Attaching package: 'mosaic'
##
## The following objects are masked from 'package:dplyr':
##
##     count, do, tally
##
## The following object is masked from 'package:car':
##
##     logit
##
```

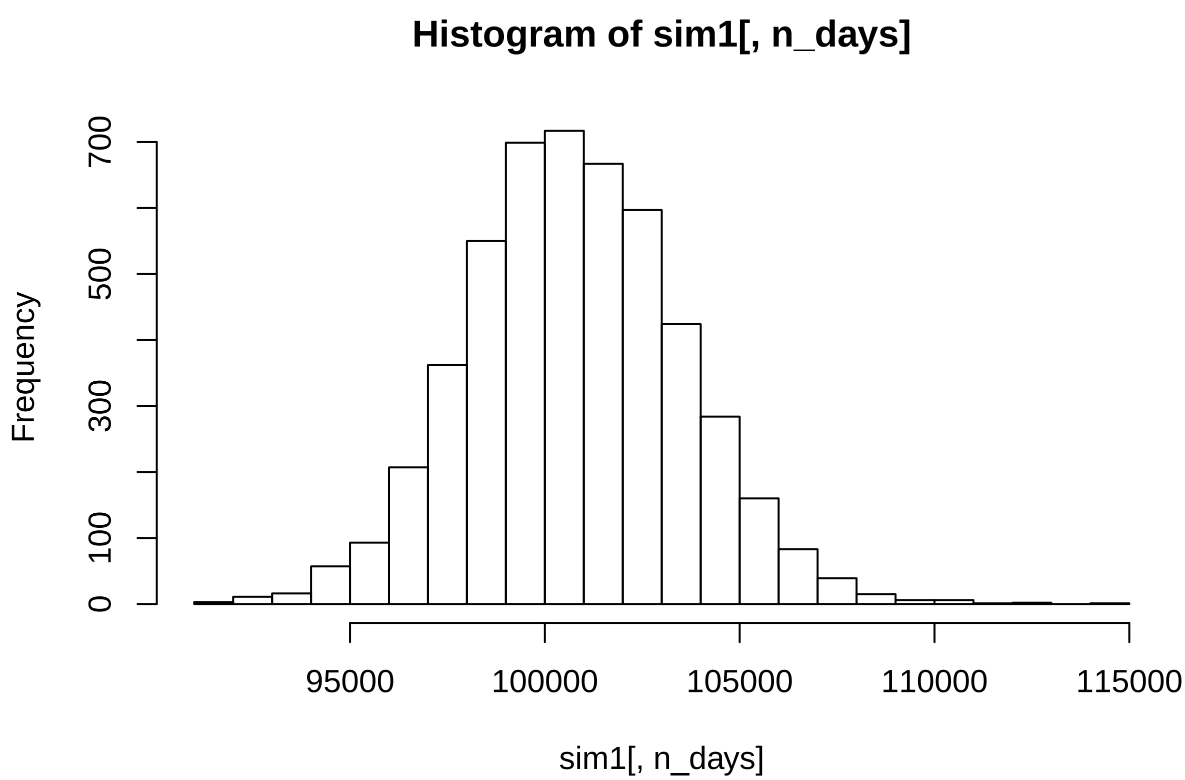
```
## The following objects are masked from 'package:timeSeries':
##
##     quantile, sample
##
## The following object is masked from 'package:timeDate':
##
##     sample
##
## The following objects are masked from 'package:stats':
##
##     binom.test, cor, cov, D, fivenum, IQR, median, prop.test,
##     quantile, sd, t.test, var
##
## The following objects are masked from 'package:base':
##
##     max, mean, min, prod, range, sample, sum
```

```r
sim1 = foreach(i=1:5000, .combine='rbind') %do% {
  n_days = 20
    totalwealth = 100000
    weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
    holdings = weights * totalwealth
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(returns, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        totalwealth = sum(holdings)
        wealthtracker[today] = totalwealth
    }
    wealthtracker
}

head(sim1)
```

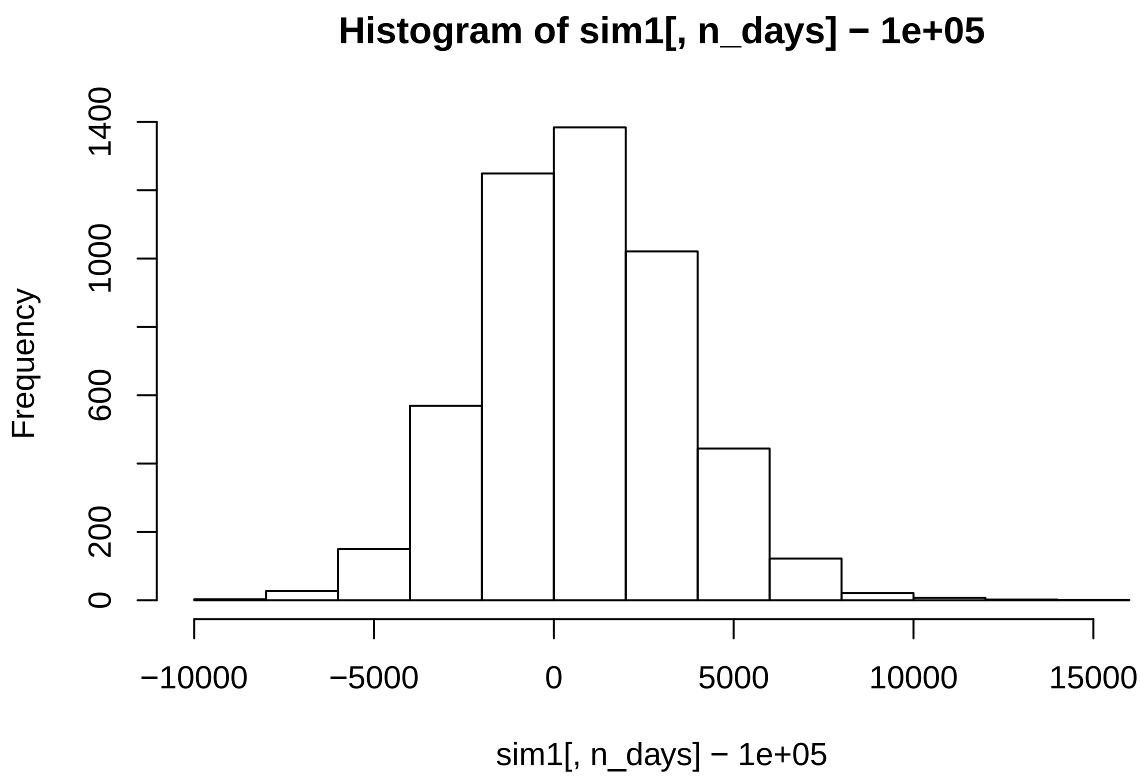
```
##               [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## result.1  99491.03  98631.17  98927.34  99197.07  99046.27  97700.71
## result.2 100860.31 101179.73 101197.17 101735.30 101222.40 101789.94
## result.3 100072.61  99580.72  99543.22 100350.97 100069.08  98871.73
## result.4  99631.04  99647.65 100167.76  99709.33 101239.30 101514.38
## result.5  99778.07 100348.41 101280.26 101134.23 100335.92  99885.18
## result.6  99584.99  98897.30  98428.64  97380.59  97217.66  97182.62
##               [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1  97582.23  97193.17  95950.99  95061.74  95283.43  94595.93
## result.2 102463.17 102844.79 102498.95 103576.62 103712.89 103828.76
## result.3  99061.24  99220.26  99542.35  99522.36  99686.50 100167.19
## result.4 101617.50 102019.60 102609.98 103325.23 104083.37 104463.22
## result.5 100125.04  99894.55 100206.25 100182.89 101153.32 100826.12
## result.6  97328.06  97862.51  97915.12  96701.67  96945.03  97954.46
##              [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1  95010.68  95618.70  95980.96  95688.23  95899.61  95852.62
## result.2 104972.69 104624.63 104949.70 103858.73 104153.05 104227.03
## result.3  99665.13  99659.62 100194.05 100452.18 100519.43 101103.78
## result.4 103713.35 104718.56 104845.89 104956.80 104955.30 105053.26
## result.5 101696.13 101636.65 101694.61 101420.94 101683.61 102385.90
```

```
## result.6  97531.20  98254.57  98383.24  97721.69  96678.84  96232.21
##               [,19]      [,20]
## result.1  96859.92  96392.70
## result.2 103984.68 104682.08
## result.3 100638.23 101271.36
## result.4 105467.37 105308.47
## result.5 101990.15 102626.18
## result.6  96060.98  95865.06
```

```
hist(sim1[,n_days], 25)
```




```
# Profit/loss
hist(sim1[,n_days]- 100000)
```




```r
# Calculate 5% value at risk
quantile(sim1[,n_days], 0.05) - 100000
```

```
##        5%
## -3592.136
```

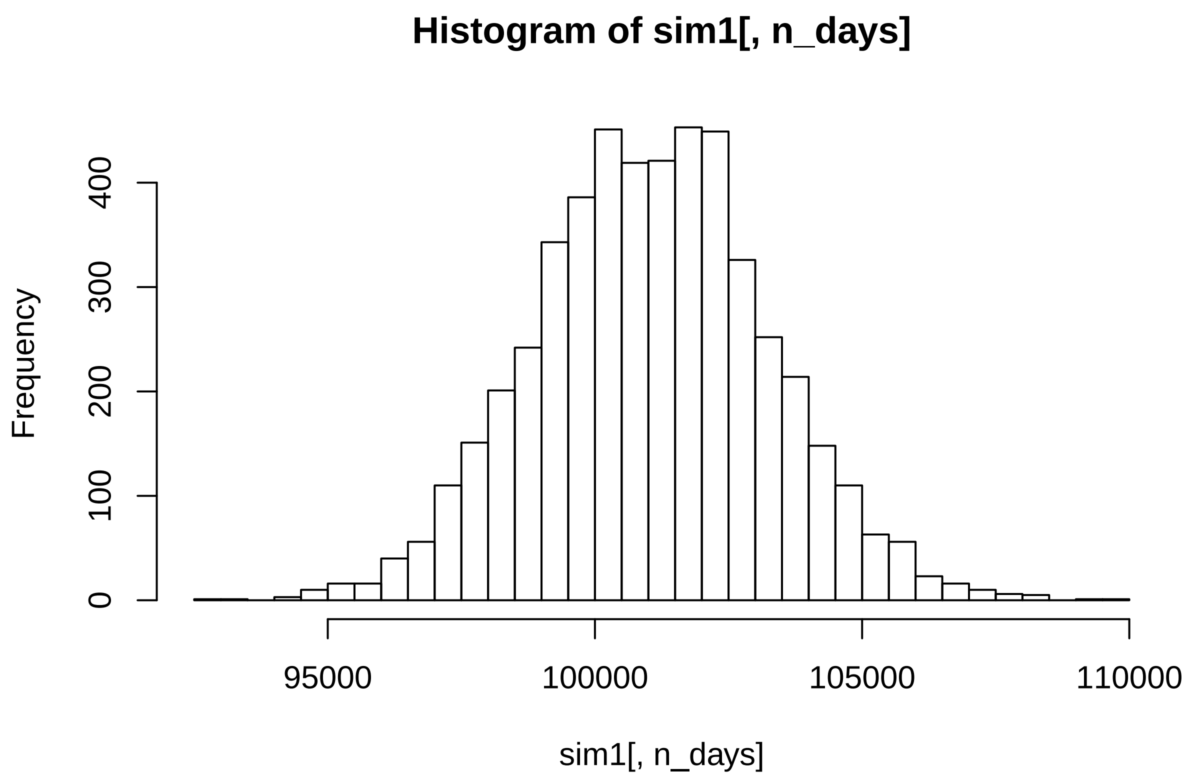
This histogram shows us where each sample lands. We can see that the majority of the time, an evenly spread portfolio will mostly return a positive amount. We can also see that by choosing this portfolio, your 5% risk is about $3600.

Safer distribution portfolio (60% in SPY, 35% in TLT, 5% in LQD):

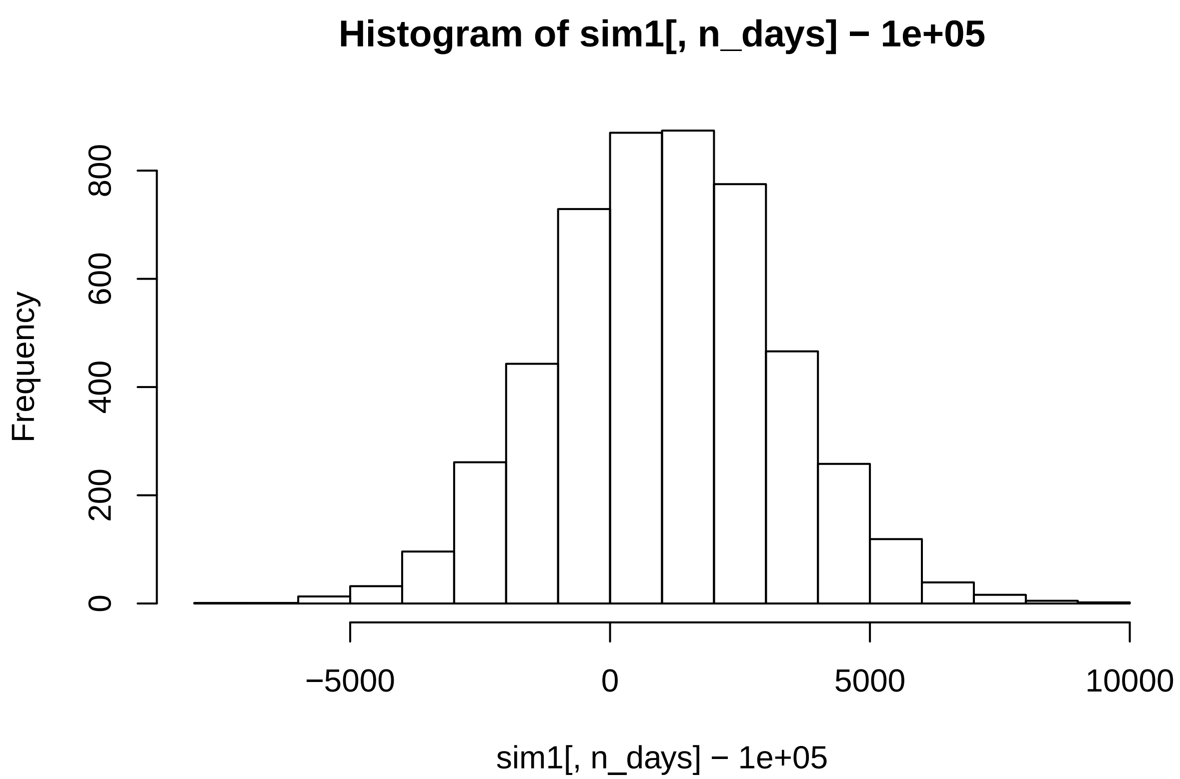
```r
sim1 = foreach(i=1:5000, .combine='rbind') %do% {
  n_days = 20
    totalwealth = 100000
    weights = c(0.6, 0.35, 0.05, 0 ,0)
    holdings = weights * totalwealth
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(returns, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        totalwealth = sum(holdings)
        wealthtracker[today] = totalwealth
    }
    wealthtracker
}

head(sim1)
```

```
##                [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## result.1  99867.83  99711.62  99485.48  99448.85  98942.40  97826.70
## result.2  99962.16 100852.93 100996.83 101884.68 101978.78 101883.51
## result.3 100551.68 100987.54 101431.75 100933.38 100190.74 100414.44
## result.4  99296.39  99421.86  99643.40  99155.83  99568.51  99235.11
## result.5  99360.64  99433.15 101142.16 101623.52 101813.77 102194.30
## result.6  99617.25  99486.28  99655.81 100052.37 100177.72 100459.53
##                [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1  97722.52  98627.11  98870.62  99110.73  99037.42  98515.21
## result.2 100865.80 101460.55 101720.17 102345.33 102586.78 103019.50
## result.3 100256.67  99839.27 100363.89  97664.90  98294.95  98641.74
## result.4  99376.19  99465.49  99298.82  98641.64  98411.24  98266.81
## result.5 102597.76 102716.57 102794.41 102855.39 102741.42 103413.93
## result.6 100005.82 100139.79  99710.96  99613.06  99455.02  99587.05
##               [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1  98535.00  98115.83  97624.69  97290.86  97142.97  96927.08
## result.2 102844.86 102992.37 103082.99 102926.95 103349.95 103353.75
## result.3  98168.48  98149.27  98548.40  98393.78  98116.40  98378.26
## result.4  98120.32  98209.32  98925.61  98754.79  98902.78  99088.79
## result.5 103715.78 103867.37 104018.36 104245.54 103995.52 103979.06
## result.6  99488.18  99389.48  99577.33  99386.92  99599.94  99554.48
##               [,19]     [,20]
## result.1  97170.66  97692.64
## result.2 103507.23 103722.23
## result.3  99037.14  99100.64
## result.4  99313.69  98988.50
## result.5 103810.90 104275.25
## result.6  99431.58 100238.72
```

```r
hist(sim1[,n_days], 25)
```




```
# Profit/loss
hist(sim1[,n_days]- 100000)
```



```r
# Calculate 5% value at risk
quantile(sim1[,n_days], 0.05) - 100000
```

```
##        5%
## -2504.077
```

```r
#50% in SPY, 50% in TLT
#5%: ~$2600
```

We can see that the majority of the time, an evenly spread portfolio will mostly return a positive amount. We can also see that by choosing this portfolio, your 5% risk is about $2500.

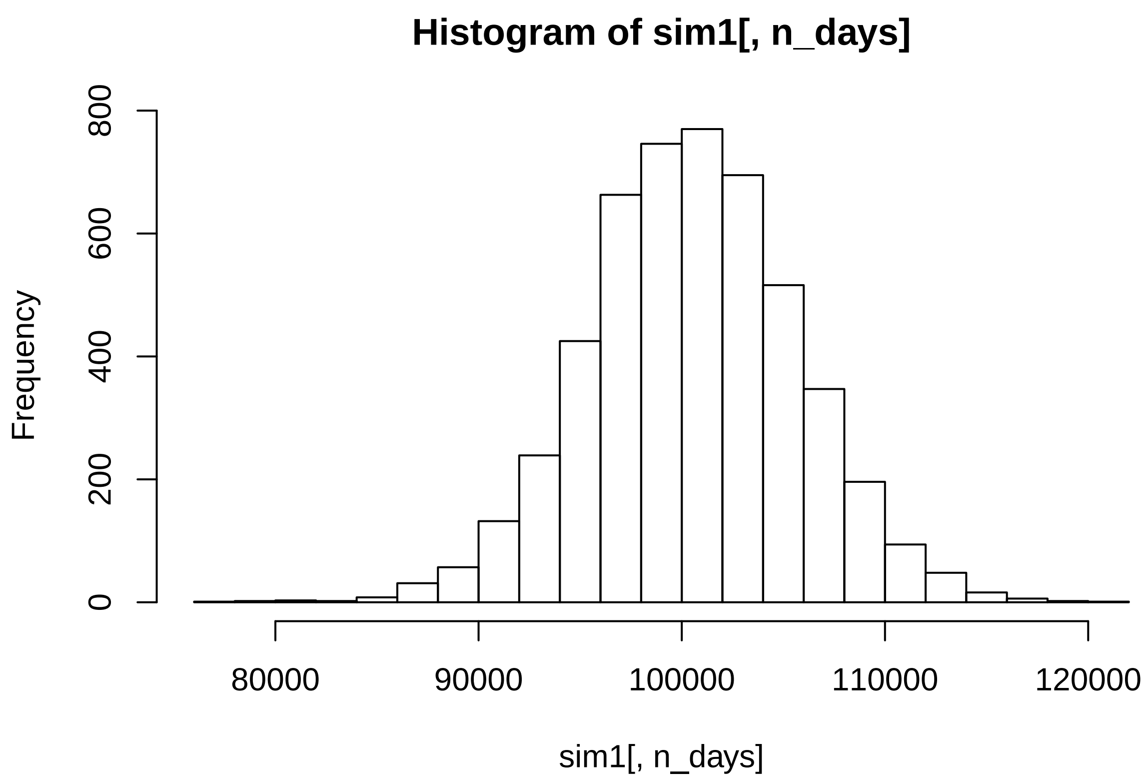
Riskier Distribution Portfolio(50/50 in EEM and VNQ):

```r
sim1 = foreach(i=1:5000, .combine='rbind') %do% {
  n_days = 20
    totalwealth = 100000
    weights = c(0, 0, 0, 0.5, 0.5)
    holdings = weights * totalwealth
    wealthtracker = rep(0, n_days)
    for(today in 1:n_days) {
        return.today = resample(returns, 1, orig.ids=FALSE)
        holdings = holdings + holdings*return.today
        totalwealth = sum(holdings)
        wealthtracker[today] = totalwealth
    }
    wealthtracker
}

head(sim1)
```

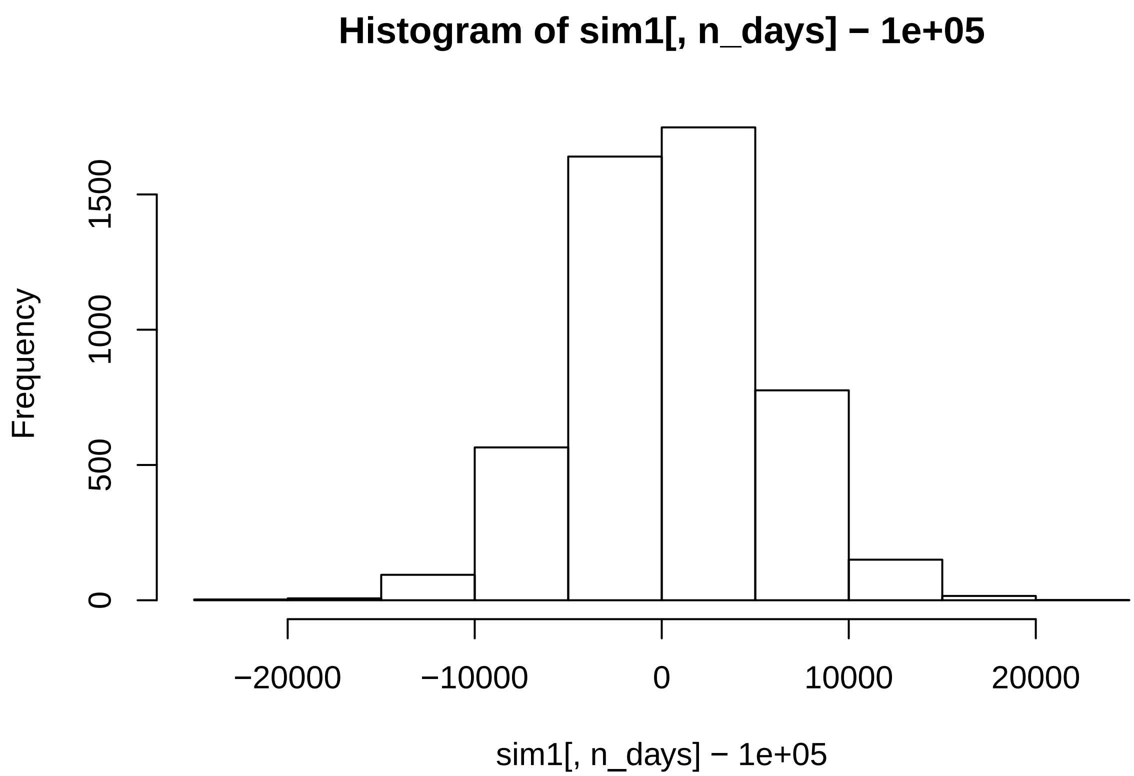
```
##               [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## result.1  97127.51  97031.36  97273.46  96313.30  95798.15  95779.82
## result.2  99667.84  98639.02  97688.37  96909.42  97160.80  98641.56
## result.3 100136.20  99768.36 102750.71 103119.99 101002.96 100998.25
## result.4 100139.83 102021.11 102532.38 101662.11 100350.37 100229.20
## result.5  99980.49 101814.19 103782.45 104305.36 102544.28 101665.12
## result.6 100470.03 100223.19  99107.11  97834.22  97160.08  96158.95
##               [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
## result.1  95345.54  94935.90  95179.96  94895.64  94309.84  93378.73
## result.2  98384.29  99282.42  98103.22  98485.15  95960.64  95680.37
## result.3 102473.61 102629.04 102166.00 101805.51 102313.97 104856.79
## result.4 100622.18 102164.13 102810.02 102467.03 103312.58 104512.88
## result.5 101464.25 102935.16 102518.84 102282.33 103771.65 102706.57
## result.6  96657.22  97184.51  97983.04  98114.36  97504.49  97091.14
##              [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
## result.1  93020.92  93166.50  94663.47  95292.01  94821.84  95270.28
## result.2  96109.76  96606.38  97300.96  97786.35  97557.39  97143.29
## result.3 105071.80 103947.97 103506.37 104591.10 106021.53 106780.64
## result.4 104259.61 104987.55 105147.10 104669.60 105548.51 103856.88
## result.5 102105.60 102573.41 102133.29 104071.17 102827.97 102497.96
## result.6  98612.90  99333.32  98863.34  99245.08  99065.44  98261.73
##              [,19]     [,20]
```

```
## result.1  95252.12  94134.65
## result.2  97982.52  98108.13
## result.3 106977.14 107072.22
## result.4 103361.70 103193.21
## result.5 102264.68 104223.06
## result.6 100138.54  99401.25
```

```r
hist(sim1[,n_days], 25)
```




```r
# Profit/loss
hist(sim1[,n_days]- 100000)
```




```r
# Calculate 5% value at risk
quantile(sim1[,n_days], 0.05) - 100000
```

```
##        5%
## -7808.247
```

```r
#5% risk: ~$7600
```

We can see that the majority of the time, an evenly spread portfolio will return a positive amount as often as it will return a negative amount. We can also see that by choosing this portfolio, your 5% risk is about $7600.

Therefore if you would like a consistent return on your investment, choosing the safe portfolio is your best bet. However, if you are willing to take about a $7600 bet, than your return could be much larger.

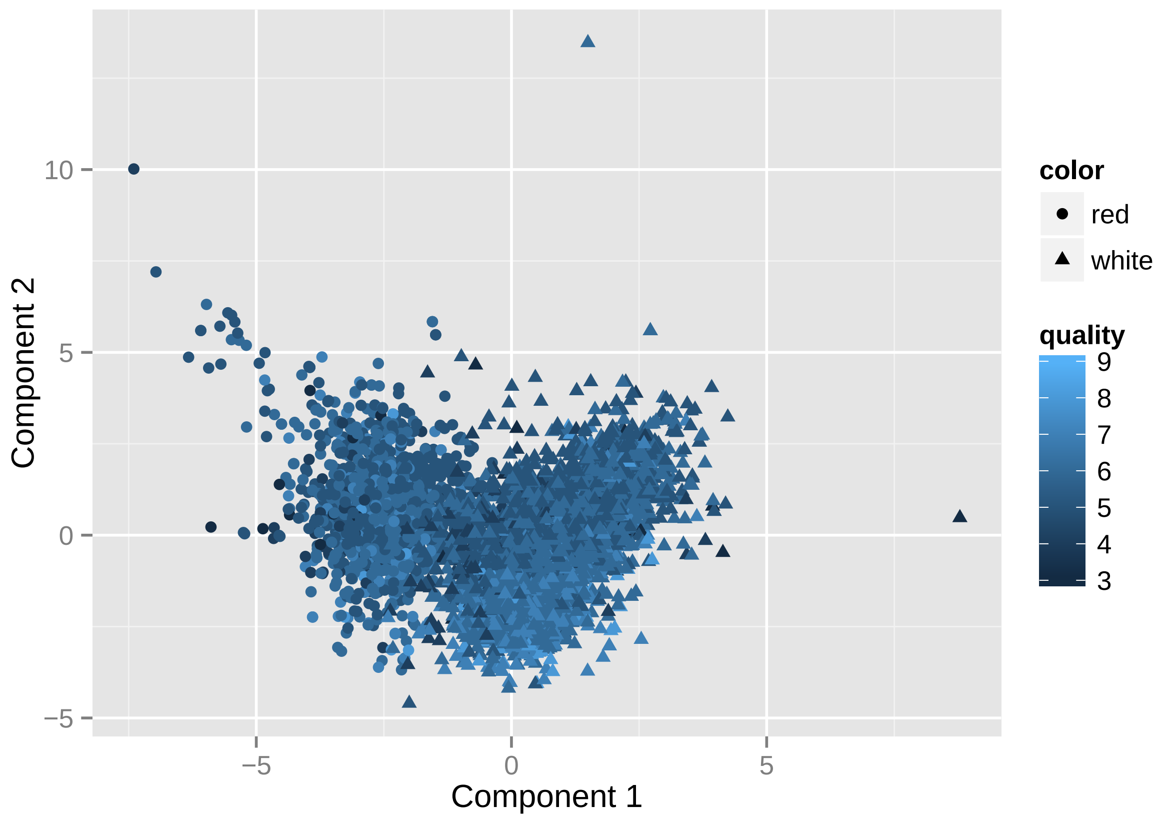
Problem 3

Is clustering or PCA better at interpreting the data on wines?

Principal Component Analysis on the 11 chemical indicators of the wine:

```r
library(ggplot2)
winedata = read.csv('../HW1/wine.csv', header = TRUE)
attach(winedata)


Z = winedata[,1:11]
```

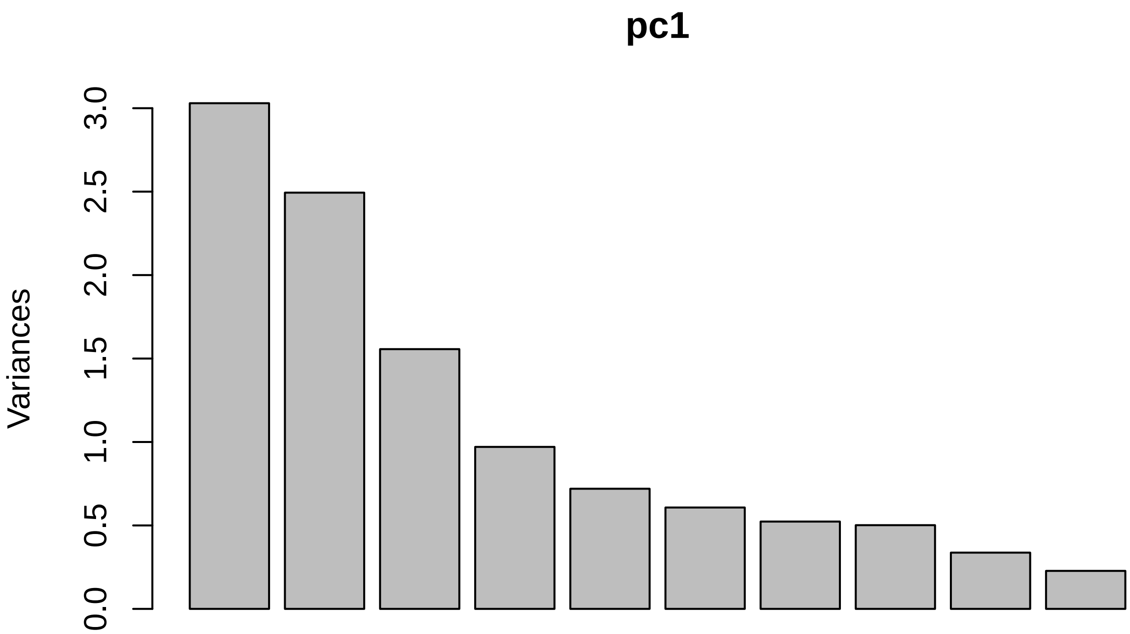
```r
# PCA
pc1 = prcomp(Z, scale=TRUE)
loadings = pc1$rotation
scores = pc1$x

qplot(scores[,1], scores[,2], color=quality, shape = color, xlab='Component 1', ylab='Component 2')
```




```r
summary(pc1)
```

```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6
## Standard deviation     1.7407 1.5792 1.2475 0.98517 0.84845 0.77930
## Proportion of Variance 0.2754 0.2267 0.1415 0.08823 0.06544 0.05521
## Cumulative Proportion  0.2754 0.5021 0.6436 0.73187 0.79732 0.85253
##                            PC7     PC8     PC9   PC10    PC11
## Standard deviation     0.72330 0.70817 0.58054 0.4772 0.18119
## Proportion of Variance 0.04756 0.04559 0.03064 0.0207 0.00298
## Cumulative Proportion  0.90009 0.94568 0.97632 0.9970 1.00000
```

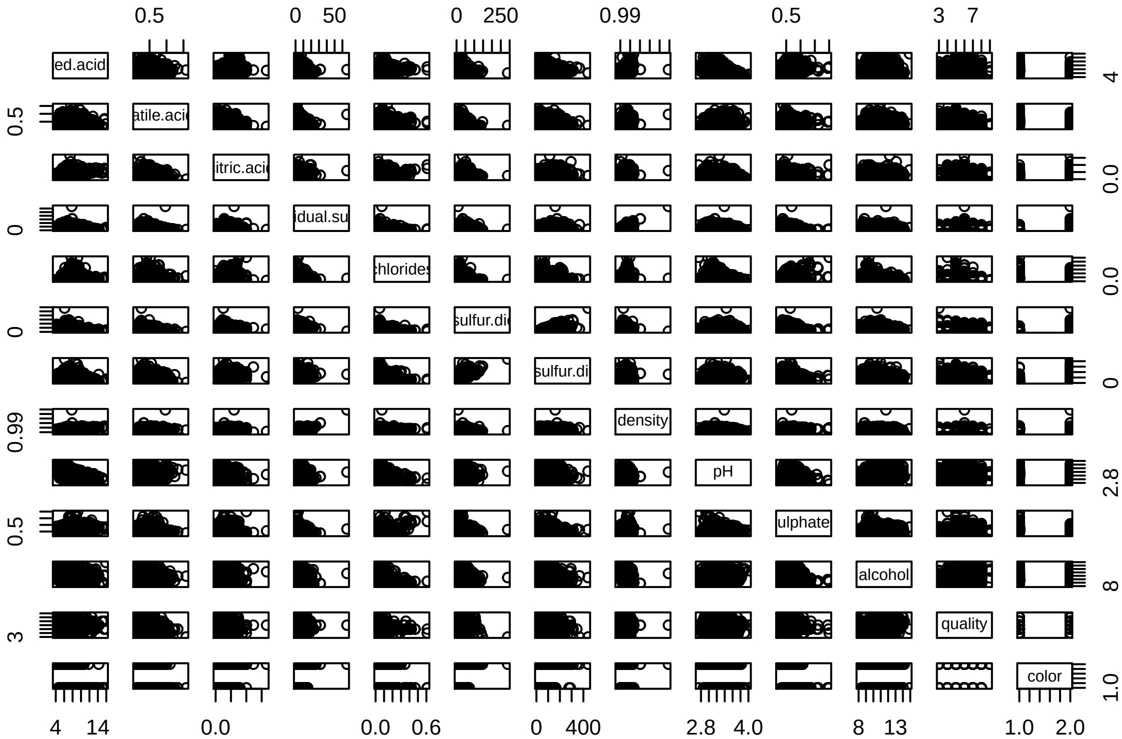
```r
plot(pc1)
```



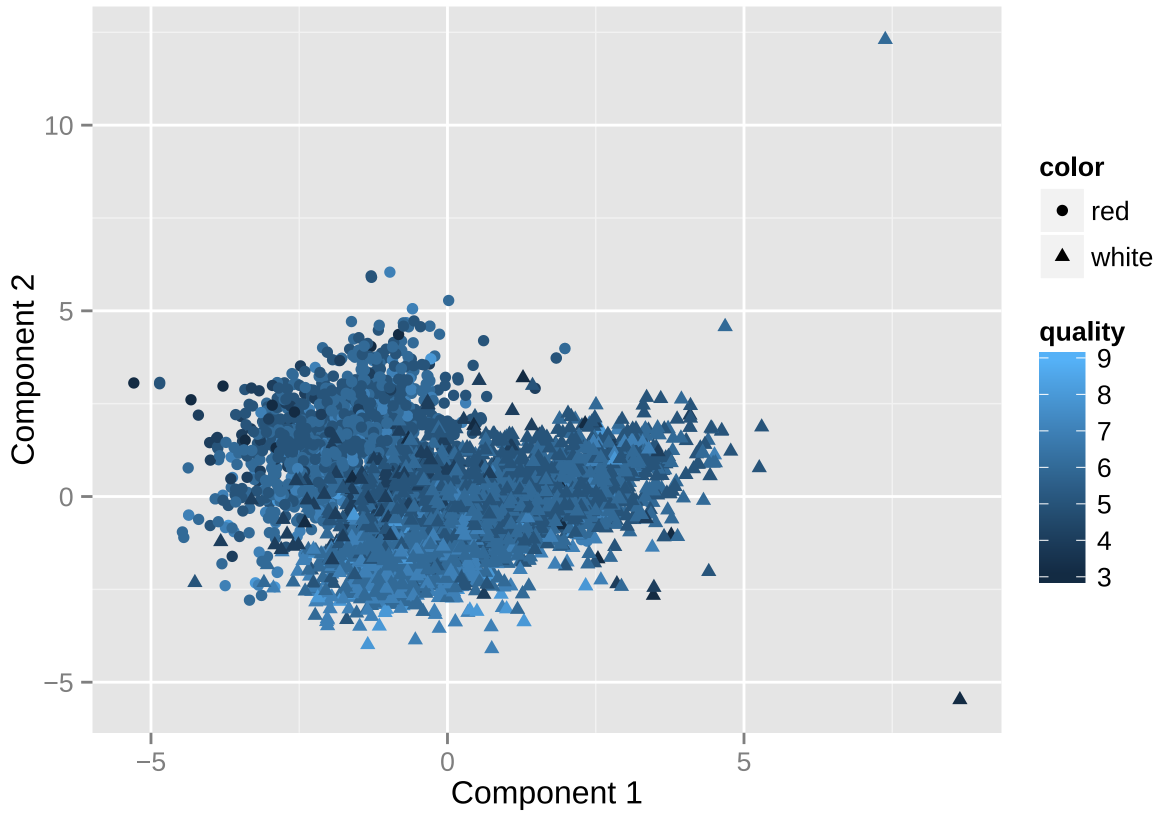
With all 11 chemical indicators taken into account, the first principal component takes into account about 27% of the variance, as we can see from the summary of the principal component. I would ideally like to keep a plot that separates whites versus reds and that explains quality somewhat, but also has a higher proportion of variance for PC1.

By plotting each of the variables against one another using the pairs() function, I looked at the chemical variables where it looked they had a high association with either color or quality. I reran PCA using only these variables.

```r
pairs(winedata)
```



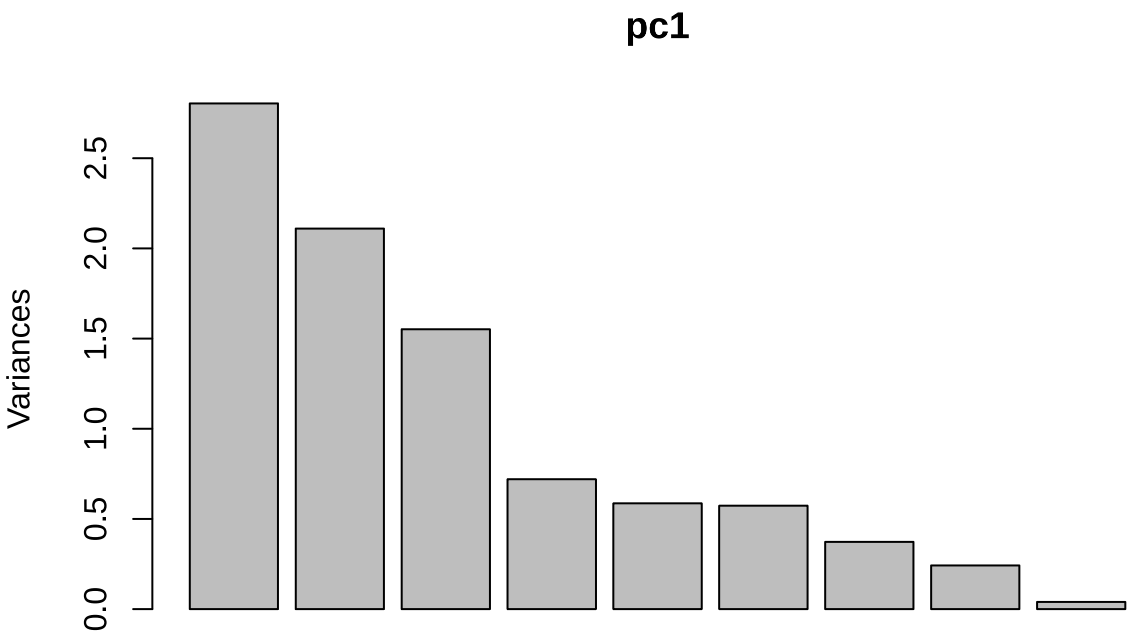

```r
Z = winedata[,c(1,2,3,4,6,7,8,9,11)]

# PCA
pc1 = prcomp(Z, scale=TRUE)
loadings = pc1$rotation
scores = pc1$x

qplot(scores[,1], scores[,2], color=quality, shape = color, xlab='Component 1', ylab='Component 2')
```




```
summary(pc1)
```

```
## Importance of components:
##                           PC1    PC2    PC3     PC4     PC5     PC6
## Standard deviation     1.6744 1.4525 1.2457 0.84866 0.76590 0.75720
## Proportion of Variance 0.3115 0.2344 0.1724 0.08002 0.06518 0.06371
## Cumulative Proportion  0.3115 0.5460 0.7184 0.79838 0.86356 0.92726
##                            PC7     PC8     PC9
## Standard deviation     0.61059 0.49192 0.19961
## Proportion of Variance 0.04142 0.02689 0.00443
## Cumulative Proportion  0.96869 0.99557 1.00000
```

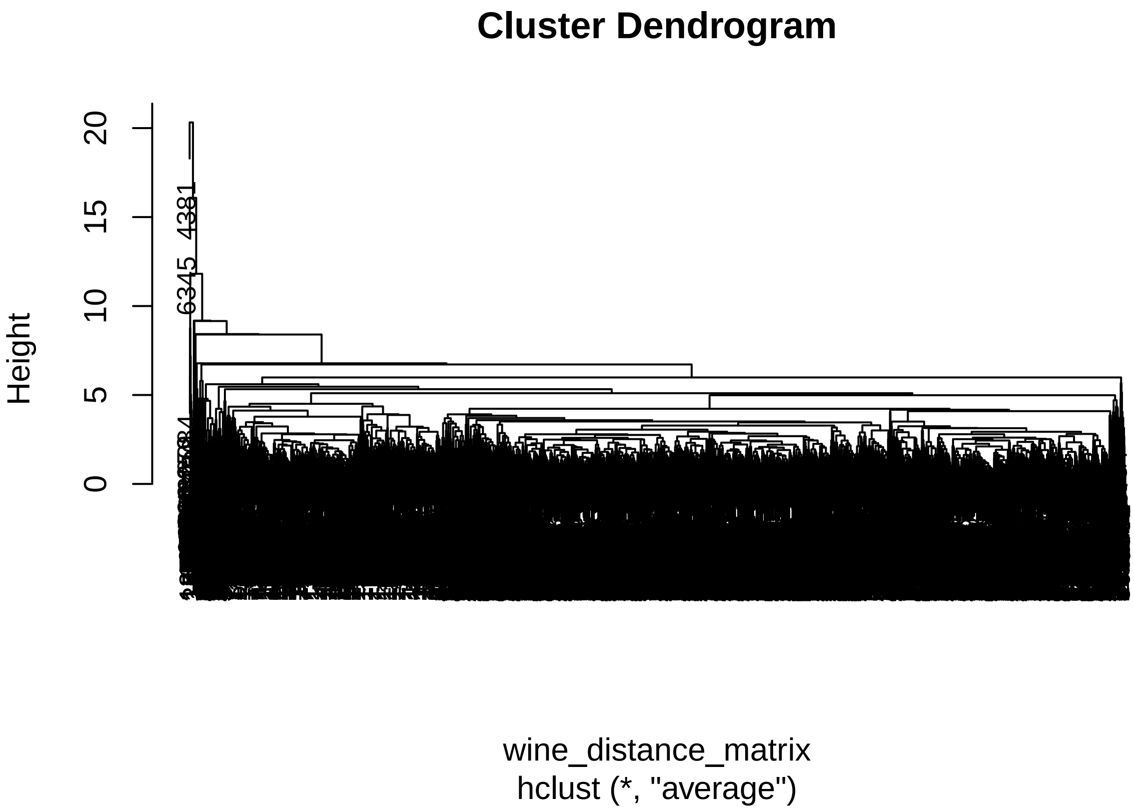
```
plot(pc1)
```



The summary shows that we succeeded in capturing more of the variance in PC1 than we had previously when we included all 11 chemical indicators. The qplot also shows that high quality wines are closer together in the bottom left corner and that as the wines decrease in quality, it becomes more obvious through the other indicators whether the wine is a red or a white.

Hierarchical clustering analysis:

```
wineh <- read.csv('../HW1/wine.csv', header = TRUE)

Y = wineh[,1:11]

wine_scaled <- scale(Y, center=TRUE, scale=TRUE)

# Form a pairwise distance matrix using the dist function
wine_distance_matrix = dist(wine_scaled, method='euclidean')

# Now run hierarchical clustering
hier_wine = hclust(wine_distance_matrix, method='average')


# Plot the dendrogram
plot(hier_wine, cex=0.8)
```




```r
# Cut the tree into 10 clusters
cluster1 = cutree(hier_wine, k=10)
summary(factor(cluster1))
```

```
##    1    2    3    4    5    6    7    8    9   10
## 6454    6   22    2    6    1    2    2    1    1
```

```r
# Examine the cluster members
which(cluster1 == 1)
```

```
##     [1]    1    2    3    4    5    6    7    8    9   10   11   12   13
##    [14]   15   16   17   19   21   22   23   24   25   26   27   28   29
##    [27]   30   31   32   33   34   35   36   37   38   39   40   41   42
##    [40]   44   45   46   47   48   49   50   51   52   53   54   55   56
##    [53]   57   58   59   60   61   62   63   64   65   66   67   68   69
##    [66]   70   71   72   73   74   75   76   77   78   79   80   81   83
##    [79]   85   86   88   89   90   91   94   95   96   97   98   99  100
##    [92]  101  102  103  104  105  106  108  109  110  111  112  113  114
##   [105]  115  116  117  118  119  120  121  122  123  124  125  126  127
##   [118]  128  129  130  131  132  133  134  135  136  137  138  139  140
##   [131]  141  142  143  144  145  146  147  148  149  150  151  153  154
##   [144]  155  156  157  158  159  160  161  162  163  164  165  166  167
##   [157]  168  169  171  172  173  174  175  176  177  178  179  180  181
##   [170]  183  184  185  186  187  188  189  190  191  192  193  194  195
##   [183]  196  197  198  199  200  201  202  203  204  205  206  207  208
##   [196]  209  210  211  212  213  214  215  216  217  218  219  220  221
##   [209]  222  223  224  225  226  228  229  230  231  232  233  234  235
```

```
## [222] 236 237 238 239 240 242 243 244 245 246 247 248 249
## [235] 250 251 252 253 254 255 256 257 258 260 261 262 263
## [248] 264 265 266 267 268 269 270 271 272 273 274 275 276
## [261] 277 278 279 280 281 283 284 285 286 287 288 289 290
## [274] 291 293 294 295 296 297 298 299 300 301 302 303 304
## [287] 305 306 307 308 309 310 311 312 313 314 315 316 317
## [300] 318 319 320 321 322 323 324 325 326 327 328 329 330
## [313] 331 332 333 334 335 336 337 338 339 340 341 342 343
## [326] 344 345 346 347 348 349 350 351 352 353 354 355 356
## [339] 357 358 359 360 361 362 363 364 365 366 367 368 369
## [352] 370 371 372 373 374 375 376 377 378 379 380 381 382
## [365] 383 384 385 386 387 388 389 390 391 392 393 394 395
## [378] 396 397 398 399 400 401 402 403 404 405 406 407 408
## [391] 409 410 411 412 413 414 415 416 417 418 419 420 421
## [404] 422 423 424 425 426 427 428 429 430 431 432 433 434
## [417] 435 436 437 438 439 440 441 442 444 445 446 447 448
## [430] 449 450 451 453 454 455 456 457 458 459 460 461 462
## [443] 463 464 465 466 467 468 469 470 471 472 473 474 475
## [456] 476 477 478 479 480 481 482 483 484 485 486 487 488
## [469] 489 490 491 492 493 494 495 496 497 498 499 500 501
## [482] 502 503 504 505 506 507 508 509 510 511 512 513 514
## [495] 515 516 517 518 519 520 521 522 523 524 525 526 527
## [508] 528 529 530 531 532 533 534 535 536 537 538 539 540
## [521] 541 542 543 544 545 546 547 548 549 550 551 552 553
## [534] 554 557 559 560 561 562 563 564 565 566 567 568 569
## [547] 570 571 572 573 574 575 576 577 578 579 580 581 582
## [560] 583 584 585 586 587 588 589 590 591 592 593 594 595
## [573] 596 597 598 599 600 601 602 603 604 605 606 607 608
## [586] 609 610 611 612 613 614 615 616 617 618 619 620 621
## [599] 622 623 624 625 626 627 628 629 630 631 632 633 634
## [612] 635 636 637 638 639 641 642 643 644 645 646 647 648
## [625] 649 650 651 652 654 655 656 657 658 659 660 661 662
## [638] 663 664 665 666 667 668 669 670 671 672 673 674 675
## [651] 676 677 678 679 680 681 682 683 684 685 686 687 688
## [664] 689 690 691 692 694 695 696 697 698 699 700 701 702
## [677] 703 704 705 706 707 708 709 710 711 712 713 714 715
## [690] 716 717 718 719 720 721 722 723 725 726 727 728 729
## [703] 730 732 733 734 735 736 737 738 739 740 741 742 743
## [716] 744 745 746 747 748 749 750 751 752 753 754 756 757
## [729] 758 759 760 761 762 763 764 765 766 767 768 769 770
## [742] 771 772 773 774 775 776 777 778 779 780 781 782 783
## [755] 784 785 786 787 788 789 790 791 792 793 794 795 796
## [768] 797 798 799 800 801 802 803 804 805 806 807 808 809
## [781] 810 811 812 813 814 815 816 817 818 819 820 821 822
## [794] 823 824 825 826 827 828 829 830 831 832 833 834 835
## [807] 836 837 838 839 840 841 842 843 844 845 846 847 848
## [820] 849 850 851 852 853 854 855 856 857 858 859 860 861
## [833] 862 863 864 865 866 867 868 869 870 871 872 873 874
## [846] 875 876 877 878 879 880 881 882 883 884 885 886 887
## [859] 888 889 890 891 892 893 894 895 896 897 898 899 900
## [872] 901 902 903 904 905 906 907 908 909 910 911 912 913
## [885] 914 915 916 917 918 919 920 921 922 923 924 925 926
## [898] 927 928 929 930 931 932 933 934 935 936 937 938 939
## [911] 940 941 942 943 944 945 946 947 948 949 950 951 952
```

```
##  [924]  953  954  955  956  957  958  959  960  961  962  963  964  965
##  [937]  966  967  968  969  970  971  972  973  974  975  976  977  978
##  [950]  979  980  981  982  983  984  985  986  987  988  989  990  991
##  [963]  992  993  994  995  996  997  998  999 1000 1001 1002 1003 1004
##  [976] 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017
##  [989] 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030
## [1002] 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043
## [1015] 1044 1045 1046 1047 1048 1049 1050 1051 1053 1054 1055 1056 1057
## [1028] 1058 1059 1060 1061 1062 1063 1064 1065 1066 1067 1068 1069 1070
## [1041] 1071 1072 1073 1074 1075 1076 1077 1078 1079 1080 1081 1082 1083
## [1054] 1084 1085 1086 1087 1088 1089 1090 1091 1092 1093 1094 1095 1096
## [1067] 1097 1098 1099 1100 1101 1102 1103 1104 1105 1106 1107 1108 1109
## [1080] 1110 1111 1112 1113 1114 1115 1116 1117 1118 1119 1120 1121 1122
## [1093] 1123 1124 1125 1126 1127 1128 1129 1130 1131 1132 1133 1134 1135
## [1106] 1136 1137 1138 1139 1140 1141 1142 1143 1144 1145 1146 1147 1148
## [1119] 1149 1150 1151 1152 1153 1154 1155 1156 1157 1158 1159 1160 1161
## [1132] 1162 1163 1164 1165 1167 1168 1169 1170 1171 1172 1173 1174 1175
## [1145] 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185 1186 1187 1188
## [1158] 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199 1200 1201
## [1171] 1202 1203 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214
## [1184] 1215 1216 1217 1218 1219 1220 1221 1222 1223 1224 1225 1226 1227
## [1197] 1228 1229 1230 1231 1232 1233 1234 1235 1236 1237 1238 1239 1240
## [1210] 1241 1242 1243 1244 1245 1246 1247 1248 1249 1250 1251 1252 1253
## [1223] 1254 1255 1256 1257 1258 1259 1260 1262 1263 1264 1265 1266 1267
## [1236] 1268 1269 1270 1271 1272 1273 1274 1275 1276 1277 1278 1279 1280
## [1249] 1281 1282 1283 1284 1285 1286 1287 1288 1289 1290 1291 1292 1293
## [1262] 1294 1295 1296 1297 1298 1299 1300 1301 1302 1303 1304 1305 1306
## [1275] 1307 1308 1309 1310 1311 1312 1313 1314 1315 1316 1317 1318 1319
## [1288] 1321 1322 1323 1324 1325 1326 1327 1328 1329 1330 1331 1332 1333
## [1301] 1334 1335 1336 1337 1338 1339 1340 1341 1342 1343 1344 1345 1346
## [1314] 1347 1348 1349 1350 1351 1352 1353 1354 1355 1356 1357 1358 1359
## [1327] 1360 1361 1362 1363 1364 1365 1366 1367 1368 1369 1370 1372 1374
## [1340] 1375 1376 1377 1378 1379 1380 1381 1382 1383 1384 1385 1386 1387
## [1353] 1388 1389 1390 1391 1392 1393 1394 1395 1396 1397 1398 1399 1400
## [1366] 1401 1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412 1413
## [1379] 1414 1415 1416 1417 1418 1419 1420 1421 1422 1423 1424 1425 1426
## [1392] 1427 1428 1429 1430 1431 1432 1433 1434 1435 1436 1437 1438 1439
## [1405] 1440 1441 1442 1443 1444 1445 1446 1447 1448 1449 1450 1451 1452
## [1418] 1453 1454 1455 1456 1457 1458 1459 1460 1461 1462 1463 1464 1465
## [1431] 1466 1467 1468 1469 1470 1471 1472 1473 1474 1475 1476 1477 1478
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## [1470] 1505 1506 1507 1508 1509 1510 1511 1512 1513 1514 1515 1516 1517
## [1483] 1518 1519 1520 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530
## [1496] 1531 1532 1533 1534 1535 1536 1537 1538 1539 1540 1541 1542 1543
## [1509] 1544 1545 1546 1547 1548 1549 1550 1551 1552 1553 1554 1555 1556
## [1522] 1557 1558 1559 1560 1561 1562 1563 1564 1565 1566 1567 1568 1569
## [1535] 1570 1571 1572 1573 1574 1575 1576 1577 1578 1579 1580 1581 1582
## [1548] 1583 1584 1585 1586 1587 1588 1589 1590 1591 1592 1593 1594 1595
## [1561] 1596 1597 1598 1599 1600 1601 1602 1603 1604 1605 1606 1607 1608
## [1574] 1609 1610 1611 1612 1613 1614 1615 1616 1617 1618 1619 1620 1621
## [1587] 1622 1623 1624 1625 1626 1627 1628 1629 1630 1631 1632 1633 1634
## [1600] 1635 1636 1637 1638 1639 1640 1641 1642 1643 1644 1645 1646 1647
## [1613] 1648 1649 1650 1651 1652 1653 1654 1655 1656 1657 1658 1659 1660
```

```
## [1626] 1661 1662 1663 1664 1665 1666 1667 1668 1669 1670 1671 1672 1673
## [1639] 1674 1675 1676 1677 1678 1679 1680 1681 1682 1683 1684 1685 1686
## [1652] 1687 1688 1689 1690 1691 1692 1693 1694 1695 1696 1697 1698 1699
## [1665] 1700 1701 1702 1703 1704 1705 1706 1707 1708 1709 1710 1711 1712
## [1678] 1713 1714 1715 1716 1717 1718 1719 1720 1721 1722 1723 1724 1725
## [1691] 1726 1727 1728 1729 1730 1731 1732 1733 1734 1735 1736 1737 1738
## [1704] 1739 1740 1741 1742 1743 1744 1745 1746 1747 1748 1749 1750 1751
## [1717] 1752 1753 1754 1755 1756 1757 1758 1759 1760 1761 1762 1763 1764
## [1730] 1765 1766 1767 1768 1769 1770 1771 1772 1773 1774 1775 1776 1777
## [1743] 1778 1779 1780 1781 1782 1783 1784 1785 1786 1787 1788 1789 1790
## [1756] 1791 1792 1793 1794 1795 1796 1797 1798 1799 1800 1801 1802 1803
## [1769] 1804 1805 1806 1807 1808 1809 1810 1811 1812 1813 1814 1815 1816
## [1782] 1817 1818 1819 1820 1821 1822 1823 1824 1825 1826 1827 1828 1829
## [1795] 1830 1831 1832 1833 1834 1835 1836 1837 1838 1839 1840 1841 1842
## [1808] 1843 1844 1845 1846 1847 1848 1849 1850 1851 1852 1853 1854 1855
## [1821] 1856 1857 1858 1859 1860 1861 1862 1863 1864 1865 1866 1867 1868
## [1834] 1869 1870 1871 1872 1873 1874 1875 1876 1877 1878 1879 1880 1881
## [1847] 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894
## [1860] 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
## [1873] 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920
## [1886] 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933
## [1899] 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946
## [1912] 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959
## [1925] 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972
## [1938] 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985
## [1951] 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
## [1964] 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
## [1977] 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
## [1990] 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037
## [2003] 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050
## [2016] 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063
## [2029] 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076
## [2042] 2077 2078 2079 2080 2081 2082 2083 2085 2086 2087 2088 2089 2090
## [2055] 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103
## [2068] 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116
## [2081] 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129
## [2094] 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142
## [2107] 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155
## [2120] 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168
## [2133] 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181
## [2146] 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194
## [2159] 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207
## [2172] 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220
## [2185] 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233
## [2198] 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246
## [2211] 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259
## [2224] 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272
## [2237] 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285
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## [5474] 5516 5517 5518 5519 5520 5521 5522 5523 5524 5525 5526 5527 5528
## [5487] 5529 5530 5531 5532 5533 5534 5535 5536 5537 5538 5539 5540 5541
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## [5669] 5711 5712 5713 5714 5715 5716 5717 5718 5719 5720 5721 5722 5723
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## [5760] 5802 5803 5804 5805 5806 5807 5808 5809 5810 5811 5812 5813 5814
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## [5799] 5841 5842 5843 5844 5845 5846 5847 5848 5849 5850 5851 5852 5853
## [5812] 5854 5855 5856 5857 5858 5859 5860 5861 5862 5863 5864 5865 5866
## [5825] 5867 5868 5869 5870 5871 5872 5873 5874 5875 5876 5877 5878 5879
```

```
## [5838] 5880 5881 5882 5883 5884 5885 5886 5887 5888 5889 5890 5891 5892
## [5851] 5893 5894 5895 5896 5897 5898 5899 5900 5901 5902 5903 5904 5905
## [5864] 5906 5907 5908 5909 5910 5911 5912 5913 5914 5915 5916 5917 5918
## [5877] 5919 5920 5921 5922 5923 5924 5925 5926 5927 5928 5929 5930 5931
## [5890] 5932 5933 5934 5935 5936 5937 5938 5939 5940 5941 5942 5943 5944
## [5903] 5945 5946 5947 5948 5949 5950 5951 5952 5953 5954 5955 5956 5957
## [5916] 5958 5959 5960 5961 5962 5963 5964 5965 5966 5967 5968 5969 5970
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## [6085] 6127 6128 6129 6130 6131 6132 6133 6134 6135 6136 6137 6138 6139
## [6098] 6140 6141 6142 6143 6144 6145 6146 6147 6148 6149 6150 6151 6152
## [6111] 6153 6154 6155 6156 6157 6158 6159 6160 6161 6162 6163 6164 6165
## [6124] 6166 6167 6168 6169 6170 6171 6172 6173 6174 6175 6176 6177 6178
## [6137] 6179 6180 6181 6182 6183 6184 6185 6186 6187 6188 6189 6190 6191
## [6150] 6192 6193 6194 6195 6196 6197 6198 6199 6200 6201 6202 6203 6204
## [6163] 6205 6206 6207 6208 6209 6210 6211 6212 6213 6214 6215 6216 6217
## [6176] 6218 6219 6220 6221 6222 6223 6224 6225 6226 6227 6228 6229 6230
## [6189] 6231 6232 6233 6234 6235 6236 6237 6238 6239 6240 6241 6242 6243
## [6202] 6244 6245 6246 6247 6248 6249 6250 6251 6252 6253 6254 6255 6256
## [6215] 6257 6258 6259 6260 6261 6262 6263 6264 6265 6266 6267 6268 6269
## [6228] 6270 6271 6272 6273 6274 6275 6276 6277 6278 6279 6280 6281 6282
## [6241] 6283 6284 6285 6286 6287 6288 6289 6290 6291 6292 6293 6294 6295
## [6254] 6296 6297 6298 6299 6300 6301 6302 6303 6304 6305 6306 6307 6308
## [6267] 6309 6310 6311 6312 6313 6314 6315 6316 6317 6318 6319 6320 6321
## [6280] 6322 6323 6324 6325 6326 6327 6328 6329 6330 6331 6332 6333 6334
## [6293] 6335 6336 6337 6338 6339 6340 6341 6342 6343 6344 6346 6347 6348
## [6306] 6349 6350 6351 6352 6353 6354 6355 6356 6357 6358 6359 6360 6361
## [6319] 6362 6363 6364 6365 6366 6367 6368 6369 6370 6371 6372 6373 6374
## [6332] 6375 6376 6377 6378 6379 6380 6381 6382 6383 6384 6385 6386 6387
## [6345] 6388 6389 6390 6391 6392 6393 6394 6395 6396 6397 6398 6399 6400
## [6358] 6401 6402 6403 6404 6405 6406 6407 6408 6409 6410 6411 6412 6413
## [6371] 6414 6415 6416 6417 6418 6419 6420 6421 6422 6423 6424 6425 6426
## [6384] 6427 6428 6429 6430 6431 6432 6433 6434 6435 6436 6437 6438 6439
## [6397] 6440 6441 6442 6443 6444 6445 6446 6447 6448 6449 6450 6451 6452
## [6410] 6453 6454 6455 6456 6457 6458 6459 6460 6461 6462 6463 6464 6465
## [6423] 6466 6467 6468 6469 6470 6471 6472 6473 6474 6475 6476 6477 6478
## [6436] 6479 6480 6481 6482 6483 6484 6485 6486 6487 6488 6489 6490 6491
## [6449] 6492 6493 6494 6495 6496 6497
```

```
which(cluster1 == 2)
```

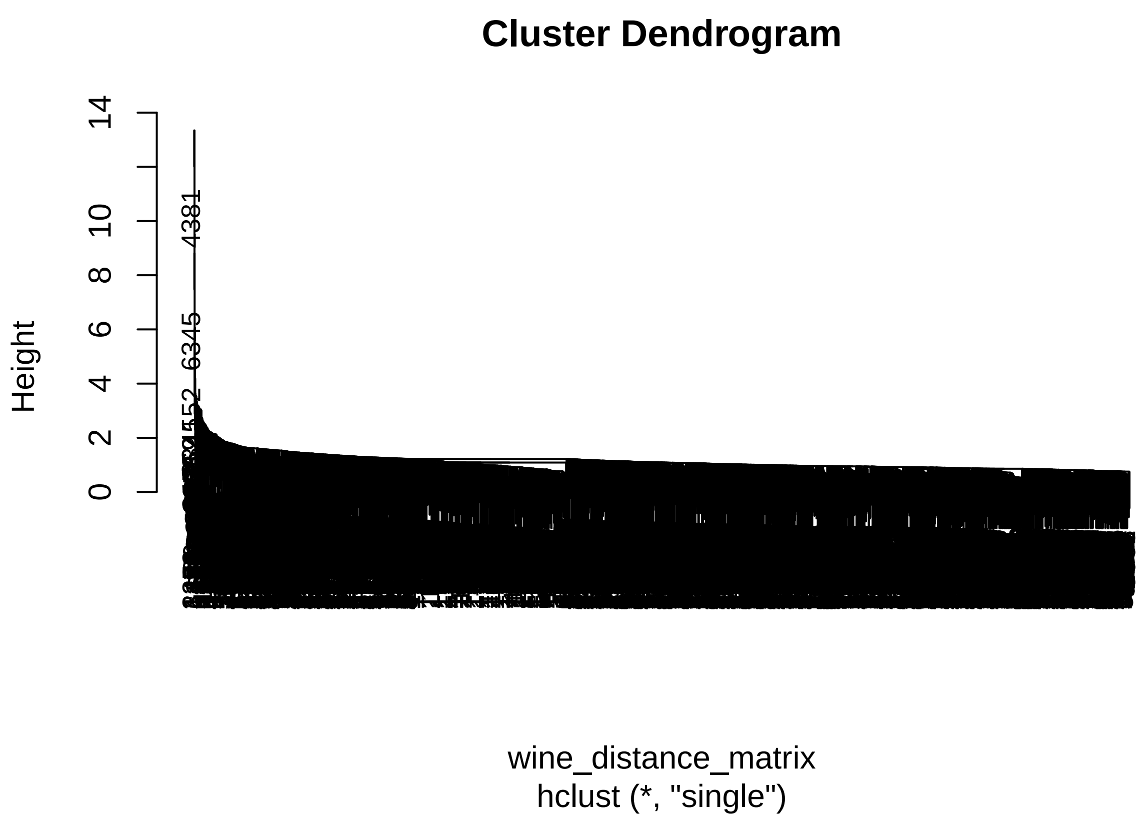
```
## [1]  14  87  92  93 640 724
```

```r
which(cluster1 == 3)
```

```
##  [1]   18   20   43   82   84  107  170  182  227  241  282  292  452  693
## [15]  731  755 1052 1166 1261 1320 1371 1373
```

```r
# Using single linkage instead
hier_wine2 = hclust(wine_distance_matrix, method='single')

# Plot the dendrogram
plot(hier_wine2, cex=0.8)
```




```r
cluster2 = cutree(hier_wine2, k=10)
summary(factor(cluster2))
```

```
##    1    2    3    4    5    6    7    8    9   10
## 6487    1    1    1    1    1    2    1    1    1
```

Hierarchical clustering using both single and complete linkage returned trees that were unintelligible. By looking at the summary of the clusters when cut into 10 clusters, we can see that the wines are not nearly evenly distributed. There are thousands of wines in the first cluster and only a few in the other 9 clusters.

Overall, using PCA with only certain variables seems like the best way to reduce the dimensionality of the wine data. It is capable of sorting the reds from the whites as well as giving an idea of the quality of the wine.

Problem 4

By runnning K-means on this data set, I was able to discerne 5 distinct groups that are posting about the product. These are an online gaming/ university group, a general chatter and picture posting group, a cooking group, a sports fandom group, and a health nutrition and fitness group. This makes sense, as the product is a sports/ hydration drink of some kind.

```
library(ggplot2)
social = read.csv('../HW1/social_marketing.csv', header = TRUE)
head(social)
```

```
##           X chatter current_events travel photo_sharing uncategorized
## 1 hmjoe4g3k       2              0      2             2             2
## 2 clk1m5w8s       3              3      2             1             1
## 3 jcsovtak3       6              3      4             3             1
## 4 3oeb4hiln       1              5      2             2             0
## 5 fd75x1vgk       5              2      0             6             1
## 6 h6nvj91yp       6              4      2             7             0
##   tv_film sports_fandom politics food family home_and_garden music news
## 1       1             1        0    4      1               2     0    0
## 2       1             4        1    2      2               1     0    0
## 3       5             0        2    1      1               1     1    1
## 4       1             0        1    0      1               0     0    0
## 5       0             0        2    0      1               0     0    0
## 6       1             1        0    2      1               1     1    0
##   online_gaming shopping health_nutrition college_uni sports_playing
## 1             0        1               17           0              2
## 2             0        0                0           0              1
## 3             0        2                0           0              0
## 4             0        0                0           1              0
## 5             3        2                0           4              0
## 6             0        5                0           0              0
##   cooking eco computers business outdoors crafts automotive art religion
## 1       5   1         1        0        2      1          0   0        1
## 2       0   0         0        1        0      2          0   0        0
## 3       2   1         0        0        0      2          0   8        0
## 4       0   0         0        1        0      3          0   2        0
## 5       1   0         1        0        1      0          0   0        0
## 6       0   0         1        1        0      0          1   0        0
##   beauty parenting dating school personal_fitness fashion small_business
## 1      0         1      1      0               11       0              0
## 2      0         0      1      4                0       0              0
## 3      1         0      1      0                0       1              0
## 4      1         0      0      0                0       0              0
## 5      0         0      0      0                0       0              1
## 6      0         0      0      0                0       0              0
##   spam adult
## 1    0     0
## 2    0     0
## 3    0     0
## 4    0     0
## 5    0     0
## 6    0     0
```

```r
attach(social)
#Normalize the subjects for each user
Y = social[,2:37]
Z = Y/rowSums(Y)
head(Z)
```

```
##      chatter current_events     travel photo_sharing uncategorized
## 1 0.03278689     0.00000000 0.03278689    0.03278689    0.03278689
## 2 0.10000000     0.10000000 0.06666667    0.03333333    0.03333333
## 3 0.12765957     0.06382979 0.08510638    0.06382979    0.02127660
## 4 0.04761905     0.23809524 0.09523810    0.09523810    0.00000000
## 5 0.16666667     0.06666667 0.00000000    0.20000000    0.03333333
## 6 0.17647059     0.11764706 0.05882353    0.20588235    0.00000000
##      tv_film sports_fandom   politics       food     family
## 1 0.01639344    0.01639344 0.00000000 0.06557377 0.01639344
## 2 0.03333333    0.13333333 0.03333333 0.06666667 0.06666667
## 3 0.10638298    0.00000000 0.04255319 0.02127660 0.02127660
## 4 0.04761905    0.00000000 0.04761905 0.00000000 0.04761905
## 5 0.00000000    0.00000000 0.06666667 0.00000000 0.03333333
## 6 0.02941176    0.02941176 0.00000000 0.05882353 0.02941176
##   home_and_garden      music      news online_gaming   shopping
## 1      0.03278689 0.00000000 0.0000000           0.0 0.01639344
## 2      0.03333333 0.00000000 0.0000000           0.0 0.00000000
## 3      0.02127660 0.02127660 0.0212766           0.0 0.04255319
## 4      0.00000000 0.00000000 0.0000000           0.0 0.00000000
## 5      0.00000000 0.00000000 0.0000000           0.1 0.06666667
## 6      0.02941176 0.02941176 0.0000000           0.0 0.14705882
##   health_nutrition college_uni sports_playing    cooking        eco
## 1        0.2786885  0.00000000     0.03278689 0.08196721 0.01639344
## 2        0.0000000  0.00000000     0.03333333 0.00000000 0.00000000
## 3        0.0000000  0.00000000     0.00000000 0.04255319 0.02127660
## 4        0.0000000  0.04761905     0.00000000 0.00000000 0.00000000
## 5        0.0000000  0.13333333     0.00000000 0.03333333 0.00000000
## 6        0.0000000  0.00000000     0.00000000 0.00000000 0.00000000
##    computers   business   outdoors     crafts automotive        art
## 1 0.01639344 0.00000000 0.03278689 0.01639344 0.00000000 0.0000000
## 2 0.00000000 0.03333333 0.00000000 0.06666667 0.00000000 0.0000000
## 3 0.00000000 0.00000000 0.00000000 0.04255319 0.00000000 0.1702128
## 4 0.00000000 0.04761905 0.00000000 0.14285714 0.00000000 0.0952381
## 5 0.03333333 0.00000000 0.03333333 0.00000000 0.00000000 0.0000000
## 6 0.02941176 0.02941176 0.00000000 0.00000000 0.02941176 0.0000000
##     religion     beauty  parenting     dating    school personal_fitness
## 1 0.01639344 0.00000000 0.01639344 0.01639344 0.0000000        0.1803279
## 2 0.00000000 0.00000000 0.00000000 0.03333333 0.1333333        0.0000000
## 3 0.00000000 0.02127660 0.00000000 0.02127660 0.0000000        0.0000000
## 4 0.00000000 0.04761905 0.00000000 0.00000000 0.0000000        0.0000000
## 5 0.00000000 0.00000000 0.00000000 0.00000000 0.0000000        0.0000000
## 6 0.00000000 0.00000000 0.00000000 0.00000000 0.0000000        0.0000000
##     fashion small_business spam adult
## 1 0.0000000     0.00000000    0     0
## 2 0.0000000     0.00000000    0     0
## 3 0.0212766     0.00000000    0     0
## 4 0.0000000     0.00000000    0     0
```

```
## 5 0.0000000     0.03333333    0     0
## 6 0.0000000     0.00000000    0     0
```

```
Z = scale(Z, center=TRUE, scale=TRUE)
mu = attr(Z,"scaled:center") #mean
sigma = attr(Z,"scaled:scale") #Standard deviation
clust1 = kmeans(Z, 5, nstart=50)
which(clust1$cluster == 1)
```

```
##    [1]    1    9   15   39   49   71   82   86   87   91  104  105  108
##   [14]  118  121  139  148  156  157  158  166  167  168  170  173  176
##   [27]  186  192  201  203  206  210  224  226  227  228  233  248  249
##   [40]  250  251  252  265  267  277  278  295  296  302  307  308  314
##   [53]  318  326  329  331  339  344  360  363  369  373  376  381  389
##   [66]  392  395  402  404  409  416  425  430  433  434  437  449  457
##   [79]  470  472  473  481  487  504  514  516  525  526  529  532  535
##   [92]  537  538  546  547  550  551  553  557  568  574  582  585  586
##  [105]  598  599  600  603  606  609  613  614  629  636  648  649  674
##  [118]  675  676  677  678  679  687  700  701  702  710  711  714  716
##  [131]  718  722  725  726  729  733  738  748  749  754  755  765  767
##  [144]  773  774  796  801  813  817  818  828  833  839  866  867  875
##  [157]  880  881  884  895  911  917  918  920  929  930  932  948  952
##  [170]  962  977  978  985  992  994 1005 1006 1007 1022 1023 1027 1035
##  [183] 1037 1044 1047 1049 1053 1054 1057 1064 1067 1071 1074 1077 1080
##  [196] 1082 1085 1096 1097 1099 1119 1126 1128 1132 1147 1151 1153 1158
##  [209] 1162 1174 1187 1189 1194 1201 1202 1206 1207 1213 1217 1224 1225
##  [222] 1228 1229 1240 1241 1242 1258 1264 1267 1268 1270 1272 1273 1281
##  [235] 1287 1290 1292 1294 1298 1304 1309 1311 1312 1316 1319 1322 1323
##  [248] 1333 1339 1342 1347 1365 1377 1382 1402 1410 1420 1427 1428 1430
##  [261] 1431 1434 1436 1440 1446 1449 1453 1455 1457 1459 1464 1468 1469
##  [274] 1470 1472 1487 1508 1511 1512 1513 1518 1519 1520 1522 1529 1532
##  [287] 1533 1540 1542 1544 1545 1547 1562 1565 1584 1588 1591 1596 1606
##  [300] 1608 1610 1620 1624 1630 1632 1642 1643 1644 1645 1653 1655 1656
##  [313] 1657 1668 1671 1673 1677 1678 1679 1680 1688 1689 1703 1707 1708
##  [326] 1710 1711 1715 1727 1728 1736 1742 1751 1764 1772 1789 1796 1807
##  [339] 1815 1817 1828 1830 1832 1845 1848 1850 1852 1853 1861 1872 1873
##  [352] 1881 1890 1894 1897 1925 1931 1942 1947 1948 1957 1959 1963 1968
##  [365] 1969 1985 1986 1995 1998 2000 2001 2009 2010 2014 2018 2025 2052
##  [378] 2055 2058 2078 2084 2086 2095 2096 2105 2115 2127 2131 2139 2140
##  [391] 2143 2152 2154 2156 2157 2159 2162 2168 2176 2182 2191 2193 2194
##  [404] 2197 2198 2200 2205 2208 2212 2214 2216 2236 2237 2238 2241 2247
##  [417] 2250 2259 2264 2268 2274 2278 2280 2282 2291 2293 2294 2295 2297
##  [430] 2298 2300 2303 2308 2309 2310 2314 2321 2327 2332 2340 2344 2353
##  [443] 2360 2378 2382 2395 2404 2405 2407 2414 2424 2425 2428 2429 2437
##  [456] 2446 2448 2451 2452 2464 2465 2473 2475 2485 2493 2497 2524 2529
##  [469] 2532 2535 2536 2545 2546 2552 2559 2568 2572 2577 2578 2588 2589
##  [482] 2593 2601 2610 2611 2619 2621 2622 2631 2635 2638 2640 2650 2656
##  [495] 2659 2663 2665 2667 2670 2674 2675 2691 2693 2696 2698 2705 2707
##  [508] 2712 2714 2721 2734 2735 2741 2742 2754 2763 2764 2766 2769 2772
##  [521] 2784 2787 2788 2793 2799 2823 2836 2837 2841 2854 2866 2869 2879
##  [534] 2881 2897 2898 2912 2916 2921 2923 2940 2948 2953 2956 2967 2969
##  [547] 2970 2973 2978 2979 2995 2996 3006 3007 3009 3013 3028 3030 3035
##  [560] 3042 3047 3049 3054 3056 3063 3084 3092 3093 3115 3116 3122 3127
##  [573] 3138 3148 3151 3152 3153 3170 3172 3182 3187 3193 3194 3196 3201
```

```
##  [586] 3204 3205 3209 3221 3224 3225 3232 3233 3242 3244 3246 3250 3255
##  [599] 3262 3267 3273 3277 3278 3287 3291 3292 3302 3322 3323 3328 3330
##  [612] 3333 3346 3350 3351 3359 3362 3364 3369 3382 3383 3385 3388 3397
##  [625] 3398 3401 3413 3415 3416 3418 3419 3423 3432 3437 3458 3461 3474
##  [638] 3475 3477 3498 3509 3513 3515 3521 3527 3530 3532 3555 3565 3570
##  [651] 3575 3576 3581 3584 3595 3600 3606 3607 3615 3622 3623 3631 3636
##  [664] 3643 3645 3653 3655 3663 3666 3670 3676 3677 3679 3683 3694 3697
##  [677] 3699 3705 3707 3711 3715 3717 3718 3719 3726 3728 3735 3742 3743
##  [690] 3747 3761 3768 3782 3783 3785 3791 3794 3799 3806 3821 3822 3828
##  [703] 3830 3831 3837 3852 3857 3860 3864 3866 3873 3875 3879 3902 3922
##  [716] 3930 3933 3939 3942 3949 3951 3960 3962 3966 3976 3990 3992 3996
##  [729] 4004 4007 4011 4014 4016 4026 4027 4036 4042 4044 4050 4053 4055
##  [742] 4061 4067 4069 4071 4078 4081 4084 4085 4093 4108 4114 4116 4117
##  [755] 4119 4121 4123 4124 4137 4157 4170 4173 4178 4190 4195 4203 4209
##  [768] 4222 4229 4235 4236 4237 4241 4253 4259 4260 4262 4272 4275 4298
##  [781] 4300 4302 4305 4311 4316 4319 4324 4325 4330 4333 4349 4354 4358
##  [794] 4359 4367 4369 4375 4377 4389 4393 4398 4407 4411 4415 4431 4442
##  [807] 4458 4461 4477 4486 4492 4502 4511 4530 4533 4534 4550 4551 4557
##  [820] 4563 4569 4572 4580 4590 4591 4595 4620 4623 4625 4626 4628 4633
##  [833] 4634 4636 4640 4644 4647 4655 4670 4672 4675 4689 4694 4698 4707
##  [846] 4715 4719 4721 4727 4741 4746 4748 4753 4754 4773 4783 4784 4790
##  [859] 4791 4793 4796 4801 4802 4817 4835 4852 4853 4859 4874 4876 4883
##  [872] 4884 4888 4889 4896 4908 4918 4926 4928 4931 4934 4937 4939 4946
##  [885] 4950 4951 4954 4962 4972 4975 4976 4981 4989 4990 4991 4998 5012
##  [898] 5015 5016 5018 5028 5031 5037 5052 5053 5071 5078 5080 5082 5094
##  [911] 5097 5102 5113 5117 5118 5125 5128 5129 5130 5131 5134 5140 5146
##  [924] 5147 5151 5168 5176 5185 5187 5193 5197 5198 5199 5206 5207 5215
##  [937] 5220 5221 5223 5224 5230 5236 5240 5242 5243 5255 5256 5257 5260
##  [950] 5270 5280 5291 5293 5294 5297 5301 5306 5316 5317 5320 5340 5342
##  [963] 5347 5348 5350 5354 5355 5356 5363 5376 5388 5389 5393 5396 5415
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##  [989] 5479 5488 5489 5492 5502 5503 5504 5505 5506 5515 5517 5520 5522
## [1002] 5523 5529 5537 5551 5556 5559 5593 5606 5610 5624 5625 5632 5659
## [1015] 5660 5663 5690 5704 5709 5713 5714 5716 5719 5723 5725 5730 5735
## [1028] 5740 5745 5749 5750 5753 5755 5759 5761 5763 5775 5776 5777 5779
## [1041] 5784 5787 5789 5790 5792 5794 5795 5797 5810 5822 5824 5834 5838
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## [1067] 5927 5941 5947 5955 5963 5965 5971 5972 5973 5984 5987 5988 6014
## [1080] 6025 6034 6038 6041 6047 6054 6056 6063 6065 6066 6071 6072 6074
## [1093] 6077 6079 6089 6094 6096 6107 6113 6118 6132 6147 6149 6160 6163
## [1106] 6175 6177 6190 6198 6209 6222 6224 6228 6235 6236 6245 6256 6271
## [1119] 6273 6295 6300 6302 6314 6324 6325 6326 6331 6333 6337 6340 6341
## [1132] 6347 6350 6354 6360 6368 6370 6387 6391 6395 6398 6400 6405 6416
## [1145] 6417 6421 6427 6431 6443 6449 6451 6463 6465 6472 6485 6491 6500
## [1158] 6504 6511 6519 6526 6527 6529 6530 6531 6542 6547 6548 6552 6562
## [1171] 6564 6574 6576 6583 6591 6595 6596 6598 6615 6621 6630 6631 6638
## [1184] 6642 6647 6648 6655 6658 6679 6681 6690 6691 6704 6717 6725 6740
## [1197] 6742 6746 6749 6761 6762 6770 6771 6774 6779 6782 6785 6805 6812
## [1210] 6813 6815 6820 6826 6840 6841 6843 6845 6851 6860 6861 6871 6874
## [1223] 6875 6879 6880 6881 6891 6893 6901 6928 6942 6945 6949 6956 6959
## [1236] 6967 6969 6981 6982 6984 6988 6992 6999 7024 7025 7042 7047 7062
## [1249] 7074 7079 7083 7086 7101 7105 7106 7107 7116 7118 7122 7125 7128
## [1262] 7137 7145 7146 7152 7153 7156 7189 7190 7207 7210 7217 7228 7240
## [1275] 7244 7245 7259 7264 7266 7282 7287 7291 7296 7297 7299 7301 7308
```

```
## [1288] 7313 7322 7323 7328 7330 7336 7341 7343 7345 7350 7351 7367 7381
## [1301] 7382 7386 7387 7388 7392 7395 7402 7403 7409 7410 7411 7417 7425
## [1314] 7430 7433 7452 7453 7454 7459 7460 7465 7476 7478 7485 7488 7492
## [1327] 7495 7497 7514 7516 7521 7527 7541 7553 7560 7563 7566 7570 7571
## [1340] 7581 7585 7586 7588 7590 7597 7599 7612 7613 7614 7616 7652 7656
## [1353] 7660 7681 7687 7688 7695 7706 7709 7713 7723 7725 7729 7747 7752
## [1366] 7755 7756 7760 7766 7767 7769 7775 7787 7801 7802 7807 7814 7815
## [1379] 7820 7827 7832 7858 7864 7865 7866 7867 7875 7880
```

```
clust1$center[1,]*sigma + mu #online gaming, college_uni
```

```
##          chatter   current_events           travel    photo_sharing
##     0.0816349229     0.0349995653     0.0271700844     0.0422276298
##    uncategorized          tv_film   sports_fandom         politics
##     0.0192332044     0.0176092100     0.0217459113     0.0215870003
##             food           family  home_and_garden            music
##     0.0373860799     0.0141385532     0.0119143541     0.0133736571
##             news    online_gaming         shopping health_nutrition
##     0.0191515529     0.0179036845     0.0218093580     0.2053892068
##      college_uni   sports_playing          cooking              eco
##     0.0176037361     0.0119369979     0.0549229791     0.0154811504
##        computers         business         outdoors           crafts
##     0.0102966187     0.0077489416     0.0469119225     0.0100786239
##       automotive              art         religion           beauty
##     0.0107661449     0.0125318472     0.0129437558     0.0077750917
##        parenting           dating           school personal_fitness
##     0.0122931516     0.0169600386     0.0097372055     0.1110591237
##          fashion   small_business             spam            adult
##     0.0122364756     0.0053052659     0.0000701373     0.0060668171
```

```
clust1$center[2,]*sigma + mu #chatter, photo_sharing
```

```
##          chatter   current_events           travel    photo_sharing
##     8.067282e-02     3.666154e-02     2.873434e-02     9.434705e-02
##    uncategorized          tv_film   sports_fandom         politics
##     2.354999e-02     1.661141e-02     1.957265e-02     2.035715e-02
##             food           family  home_and_garden            music
##     1.625330e-02     1.458087e-02     1.152701e-02     2.016461e-02
##             news    online_gaming         shopping health_nutrition
##     1.496642e-02     1.740834e-02     2.655452e-02     2.912595e-02
##      college_uni   sports_playing          cooking              eco
##     2.215915e-02     1.402333e-02     1.751464e-01     8.472809e-03
##        computers         business         outdoors           crafts
##     1.134890e-02     1.017536e-02     1.293869e-02     8.957604e-03
##       automotive              art         religion           beauty
##     1.367780e-02     1.385459e-02     1.236769e-02     6.394745e-02
##        parenting           dating           school personal_fitness
##     1.160438e-02     1.191622e-02     1.514092e-02     1.677710e-02
##          fashion   small_business             spam            adult
##     9.325534e-02     7.473998e-03     4.916838e-05     5.625169e-03
```

```
clust1$center[3,]*sigma + mu #cooking
```

```
##          chatter   current_events           travel    photo_sharing
##     0.1712023113     0.0549849970     0.0372437844     0.0900906247
##    uncategorized          tv_film    sports_fandom         politics
##     0.0283940360     0.0400154124     0.0255798169     0.0260142211
##             food           family  home_and_garden            music
##     0.0216793495     0.0193490427     0.0166697875     0.0211906421
##             news   online_gaming         shopping health_nutrition
##     0.0136437144     0.0416125392     0.0513511616     0.0214994010
##      college_uni   sports_playing          cooking              eco
##     0.0568395371     0.0203899993     0.0191712980     0.0142070099
##        computers         business         outdoors           crafts
##     0.0119195200     0.0128718420     0.0096560933     0.0138486990
##       automotive              art         religion           beauty
##     0.0160204084     0.0237351723     0.0126323373     0.0091164594
##        parenting           dating           school personal_fitness
##     0.0110661852     0.0190870786     0.0140217879     0.0147633262
##          fashion   small_business             spam            adult
##     0.0141877273     0.0110726630     0.0002630035     0.0146090102
```

```
clust1$center[4,]*sigma + mu #sports fandom
```

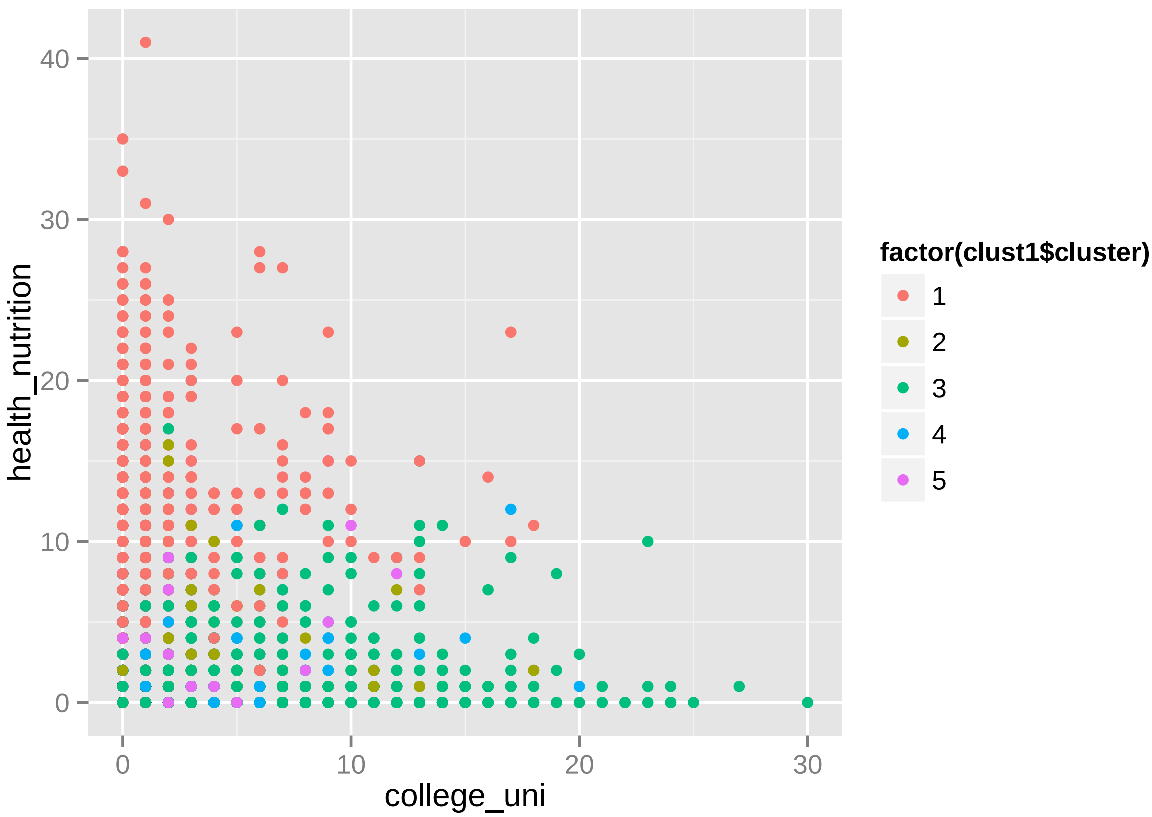
```
##          chatter   current_events           travel    photo_sharing
##     8.087602e-02     3.754866e-02     2.636845e-02     4.179289e-02
##    uncategorized          tv_film    sports_fandom         politics
##     1.632883e-02     1.969924e-02     1.027016e-01     1.926154e-02
##             food           family  home_and_garden            music
##     7.989950e-02     4.585541e-02     1.231527e-02     1.405535e-02
##             news   online_gaming         shopping health_nutrition
##     1.574497e-02     1.683987e-02     2.128892e-02     2.492943e-02
##      college_uni   sports_playing          cooking              eco
##     1.940762e-02     1.185369e-02     2.082136e-02     1.246177e-02
##        computers         business         outdoors           crafts
##     1.300058e-02     8.882964e-03     1.096123e-02     1.731307e-02
##       automotive              art         religion           beauty
##     1.729560e-02     1.444990e-02     8.936558e-02     1.762253e-02
##        parenting           dating           school personal_fitness
##     6.912127e-02     1.030298e-02     4.550617e-02     1.667805e-02
##          fashion   small_business             spam            adult
##     1.522761e-02     7.191411e-03     5.383221e-05     6.976825e-03
```

```
clust1$center[5,]*sigma + mu #health nutrition, personal fitness
```

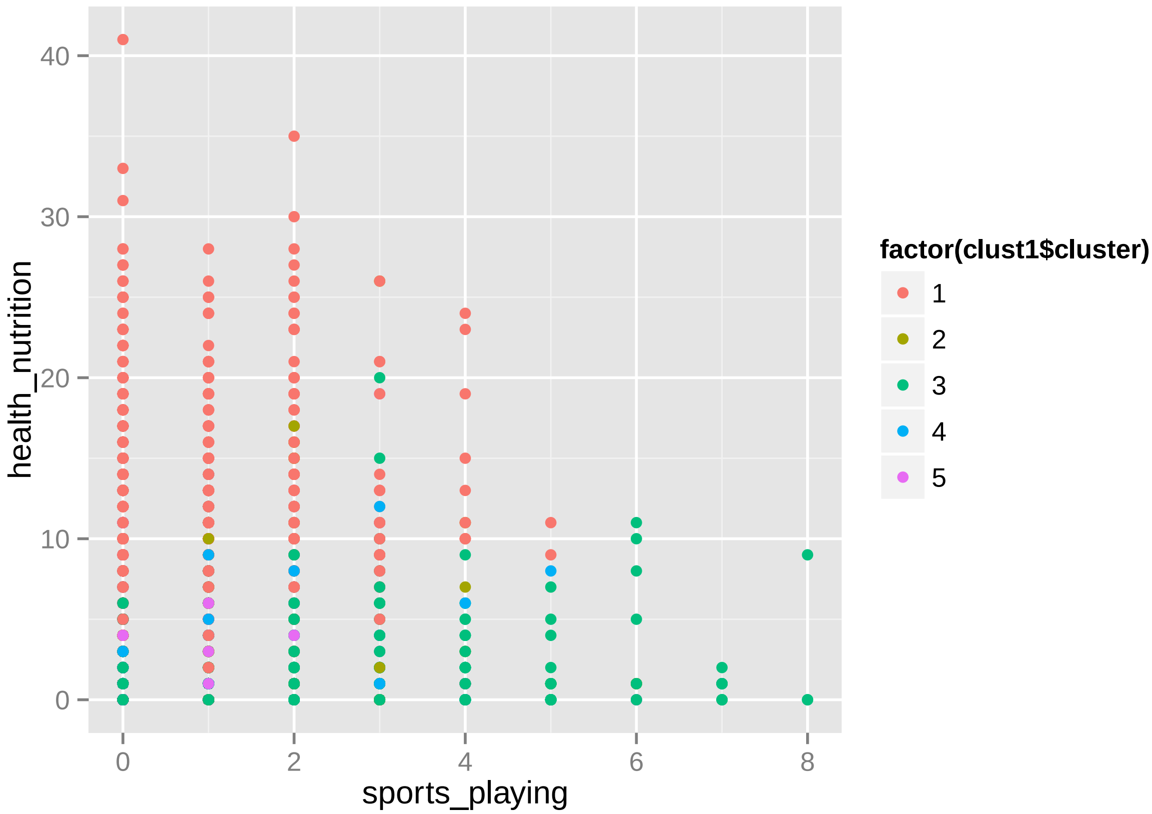
```
##          chatter   current_events           travel    photo_sharing
##     0.0886229383     0.0408938051     0.0870164434     0.0381022960
##    uncategorized          tv_film    sports_fandom         politics
##     0.0188266077     0.0239171121     0.0436408194     0.1420661155
##             food           family  home_and_garden            music
##     0.0238032877     0.0190915212     0.0127900713     0.0126398869
##             news   online_gaming         shopping health_nutrition
```

```
##      0.0982136548     0.0158030038     0.0189020060     0.0209129684
##       college_uni   sports_playing          cooking              eco
##      0.0211658229     0.0120655972     0.0177206107     0.0094062985
##         computers         business         outdoors           crafts
##      0.0353753824     0.0103493518     0.0173324001     0.0095575502
##        automotive              art         religion           beauty
##      0.0488177946     0.0101786069     0.0153190417     0.0077745769
##         parenting           dating           school personal_fitness
##      0.0170464201     0.0151016148     0.0120752515     0.0132666222
##           fashion   small_business             spam            adult
##      0.0092308554     0.0073445453     0.0001006603     0.0055284589
```

```
qplot(college_uni, health_nutrition, data=social, color=factor(clust1$cluster))
```




```
qplot(sports_playing, health_nutrition, data=social, color=factor(clust1$cluster))
```



For a sports drink, theoretically it seems like college students, athletes and sports fans would be drinking it and talking about it the most. We can see this in the two graphs above, and find that there are two main clusters that show up in the college uni vs. health nutrition graph and the sports playing vs. health nutrition graph. Cluster 1 has high beta values for online gaming and college uni and Cluster 4 has high beta values for sports fandom.