Module_03 Solution

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Load BLS data and needed additional packages

```
require(ggplot2)

## Loading required package: ggplot2

## Warning: package 'ggplot2' was built under R version 3.2.5

require(reshape2)

## Loading required package: reshape2

## Warning: package 'reshape2' was built under R version 3.2.5

require(psych)

## Loading required package: psych

## Warning: package 'psych' was built under R version 3.2.5

## 
## Attaching package: 'psych'

## The following objects are masked from 'package:ggplot2':
## 
##     %+%, alpha

memory.limit(10000)

## [1] 10000

BLS<-
read.csv("C:/Users/rams1/Desktop/DSCS6030/Module_03/2014.annual.singlefile.cs
v")
head(BLS)

##   area_fips own_code industry_code agglvl_code size_code year qtr
## 1     01000        0            10          50         0 2014   A
## 2     01000        1            10          51         0 2014   A
## 3     01000        1           102          52         0 2014   A
## 4     01000        1          1021          53         0 2014   A
## 5     01000        1          1022          53         0 2014   A
## 6     01000        1          1023          53         0 2014   A
##   disclosure_code annual_avg_estabs annual_avg_emplvl total_annual_wages
## 1                            117452           1863561        80668352987
## 2                              1186             53491         4148191291
## 3                              1186              53491         4148191291
## 4                               587              11462          719550831
## 5                                 2                 13             430575
## 6                                17                147           11630538
##   taxable_annual_wages annual_contributions annual_avg_wkly_wage
## 1          13917605638            316127565                  832
## 2                    0                    0                 1491
## 3                    0                    0                 1491
## 4                    0                    0                 1207
## 5                    0                    0                  649
## 6                    0                    0                 1527
##   avg_annual_pay lq_disclosure_code lq_annual_avg_estabs
## 1          43287                                    1.00
## 2          77550                                    1.55
## 3          77550                                    1.55
## 4          62776                                    1.55
## 5          33771                                    1.24
## 6          79389                                    1.70
##   lq_annual_avg_emplvl lq_total_annual_wages lq_taxable_annual_wages
## 1                 1.00                  1.00                       1
## 2                 1.44                  1.74                       0
## 3                 1.46                  1.77                       0
## 4                 1.26                  1.60                       0
## 5                 0.14                  0.08                       0
## 6                 0.79                  0.69                       0
##   lq_annual_contributions lq_annual_avg_wkly_wage lq_avg_annual_pay
## 1                       1                    1.00              1.00
## 2                       0                    1.21              1.21
## 3                       0                    1.22              1.21
## 4                       0                    1.27              1.27
## 5                       0                    0.55              0.55
## 6                       0                    0.88              0.88
##   oty_disclosure_code oty_annual_avg_estabs_chg
## 1                                          1394
## 2                                           -10
## 3                                           -10
## 4                                             0
## 5                                             0
## 6                                             0
##   oty_annual_avg_estabs_pct_chg oty_annual_avg_emplvl_chg
## 1                           1.2                     18475
## 2                          -0.8                     -1097
## 3                          -0.8                     -1097
## 4                           0.0                       -75
## 5                           0.0                         0
## 6                           0.0                        -7
##   oty_annual_avg_emplvl_pct_chg oty_total_annual_wages_chg
## 1                           1.0                 2665745136
## 2                          -2.0                   97930469
## 3                          -2.0                   97930469
## 4                          -0.7                   24761729
## 5                           0.0                      -7288
## 6                          -4.5                    -263697
##   oty_total_annual_wages_pct_chg oty_taxable_annual_wages_chg
## 1                            3.4                    311188704
## 2                            2.4                            0
## 3                            2.4                            0
## 4                            3.6                            0
## 5                           -1.7                            0
## 6                           -2.2                            0
##   oty_taxable_annual_wages_pct_chg oty_annual_contributions_chg
## 1                              2.3                    -70421983
## 2                              0.0                            0
## 3                              0.0                            0
## 4                              0.0                            0
## 5                              0.0                            0
## 6                              0.0                            0
##   oty_annual_contributions_pct_chg oty_annual_avg_wkly_wage_chg
## 1                            -18.2                           19
## 2                              0.0                           64
## 3                              0.0                           64
## 4                              0.0                           49
## 5                              0.0                          -25
## 6                              0.0                           43
##   oty_annual_avg_wkly_wage_pct_chg oty_avg_annual_pay_chg
## 1                              2.3                   1011
## 2                              4.5                   3353
## 3                              4.5                   3353
## 4                              4.2                   2552
## 5                             -3.7                  -1258
## 6                              2.9                   2195
##   oty_avg_annual_pay_pct_chg
## 1                        2.4
## 2                        4.5
## 3                        4.5
## 4                        4.2
## 5                       -3.6
## 6                        2.8
```

There are only some variables out of 38 variables that actually have an effect on the data. There are some which have no data at all. There are others whose numeric value has no meaning to the data. All such columns can be removed which would be useless. Hence after removing the unimportant data, I kept about 20 variables features that would be useful for the principal component analysis. I am using two methods: princomp() and principal(). Also the 'NA' values are removed before parsing the data. The included columns are: ("annual_avg_estabs","annual_avg_emplvl","total_annual_wages","annual_avg_wkly_wage","avg_annual_pay","lq_annual_avg_estabs","lq_annual_avg_emplvl","lq_total_annual_wages","lq_annual_avg_wkly_wage","lq_avg_annual_pay","oty_annual_avg_estabs_chg","oty_annual_avg_estabs_pct_chg","oty_annual_avg_emplvl_chg","oty_annual_avg_emplvl_pct_chg","oty_tot al_annual_wages_chg","oty_total_annual_wages_pct_chg","oty_annual_avg_wkly_wage_chg","oty_annual_avg_wkly_wage_pct_chg","oty_avg_annual_pay_chg","oty_avg_annual_pay_pct_chg")

```
keep <-
c("annual_avg_estabs","annual_avg_emplvl","total_annual_wages","annual_avg_wk
ly_wage","avg_annual_pay","lq_annual_avg_estabs","lq_annual_avg_emplvl","lq_t
otal_annual_wages","lq_annual_avg_wkly_wage","lq_avg_annual_pay","oty_annual_
avg_estabs_chg","oty_annual_avg_estabs_pct_chg","oty_annual_avg_emplvl_chg","
oty_annual_avg_emplvl_pct_chg","oty_total_annual_wages_chg","oty_total_annual
_wages_pct_chg","oty_annual_avg_wkly_wage_chg","oty_annual_avg_wkly_wage_pct_
chg","oty_avg_annual_pay_chg","oty_avg_annual_pay_pct_chg")

BLS_reduced = BLS[keep]
head(BLS_reduced)
```

```
##   annual_avg_estabs annual_avg_emplvl total_annual_wages
## 1            117452           1863561        80668352987
## 2              1186             53491         4148191291
## 3              1186             53491         4148191291
## 4               587             11462          719550831
## 5                 2                13             430575
## 6                17               147           11630538
##   annual_avg_wkly_wage avg_annual_pay lq_annual_avg_estabs
## 1                  832          43287                 1.00
## 2                 1491          77550                 1.55
## 3                 1491          77550                 1.55
## 4                 1207          62776                 1.55
## 5                  649          33771                 1.24
## 6                 1527          79389                 1.70
##   lq_annual_avg_emplvl lq_total_annual_wages lq_annual_avg_wkly_wage
## 1                 1.00                  1.00                    1.00
## 2                 1.44                  1.74                    1.21
## 3                 1.46                  1.77                    1.22
## 4                 1.26                  1.60                    1.27
## 5                 0.14                  0.08                    0.55
## 6                 0.79                  0.69                    0.88
##   lq_avg_annual_pay oty_annual_avg_estabs_chg
## 1              1.00                      1394
## 2              1.21                       -10
## 3              1.21                       -10
## 4              1.27                         0
## 5              0.55                         0
## 6              0.88                         0
##   oty_annual_avg_estabs_pct_chg oty_annual_avg_emplvl_chg
## 1                           1.2                     18475
## 2                          -0.8                     -1097
## 3                          -0.8                     -1097
## 4                           0.0                       -75
## 5                           0.0                         0
## 6                           0.0                        -7
##   oty_annual_avg_emplvl_pct_chg oty_total_annual_wages_chg
## 1                           1.0                 2665745136
## 2                          -2.0                   97930469
## 3                          -2.0                   97930469
## 4                          -0.7                   24761729
## 5                           0.0                      -7288
## 6                          -4.5                    -263697
##   oty_total_annual_wages_pct_chg oty_annual_avg_wkly_wage_chg
## 1                            3.4                           19
## 2                            2.4                           64
## 3                            2.4                           64
## 4                            3.6                           49
## 5                           -1.7                          -25
## 6                           -2.2                           43
##   oty_annual_avg_wkly_wage_pct_chg oty_avg_annual_pay_chg
## 1                              2.3                   1011
## 2                              4.5                   3353
## 3                              4.5                   3353
## 4                              4.2                   2552
## 5                             -3.7                  -1258
## 6                              2.9                   2195
##   oty_avg_annual_pay_pct_chg
## 1                        2.4
## 2                        4.5
## 3                        4.5
## 4                        4.2
## 5                       -3.6
## 6                        2.8
```

PCA using princomp() and principal()

```
bls.fit.A <- princomp(formula = ~., data=BLS_reduced, cor=TRUE,
na.action=na.exclude)
bls.fit.A
```

```
## Call:
## princomp(formula = ~., data = BLS_reduced, na.action = na.exclude,
##     cor = TRUE)
##
## Standard deviations:
##       Comp.1       Comp.2       Comp.3       Comp.4       Comp.5
## 2.4133123121 1.9509518995 1.6825759361 1.3894174406 1.3356196928
##       Comp.6       Comp.7       Comp.8       Comp.9      Comp.10
## 1.0547330642 0.9865858335 0.9386482159 0.6498237062 0.4017623660
##      Comp.11      Comp.12      Comp.13      Comp.14      Comp.15
## 0.3489667405 0.3110178295 0.1659228595 0.1271441265 0.1039242789
##      Comp.16      Comp.17      Comp.18      Comp.19      Comp.20
## 0.0267101313 0.0023142136 0.0020174100 0.0009982061 0.0001649254
```

```
##
##  20  variables and  3569127 observations.
```

```
library(psych)
bls.fit.B <- principal(BLS_reduced, nfactors=10, rotate="varimax")
```

```
## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
## +07, ..): not converged in 1000000 iter.

## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
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## +07, ..): not converged in 1000000 iter.

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## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
## +07, ..): not converged in 1000000 iter.

## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
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## +07, ..): not converged in 1000000 iter.

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## +07, ..): not converged in 1000000 iter.

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## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
## +07, ..): not converged in 1000000 iter.

## Warning in pchisq(chi.sq.statistic, df, ncp = lam): pnchisq(x=2.58796e
## +07, ..): not converged in 1000000 iter.
```
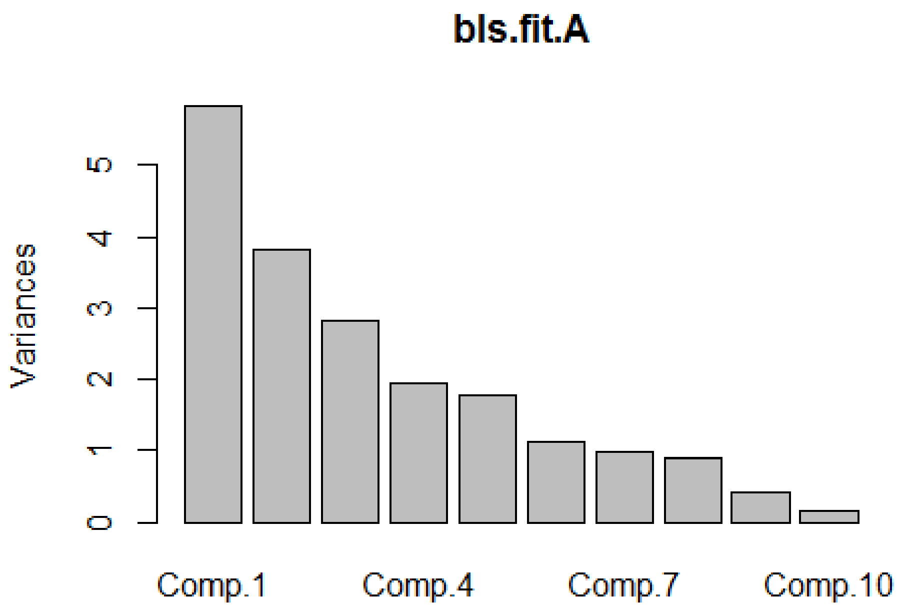

```
bls.fit.B
```

```
## Principal Components Analysis
## Call: principal(r = BLS_reduced, nfactors = 10, rotate = "varimax")
## Standardized loadings (pattern matrix) based upon correlation matrix
##                                   RC1   RC2  RC3   RC5  RC4   RC8   RC6
## annual_avg_estabs                0.99  0.00 0.00  0.00 0.00  0.00  0.00
## annual_avg_emplvl                0.99  0.00 0.00  0.00 0.00  0.00  0.00
## total_annual_wages               0.99  0.01 0.00  0.00 0.00  0.00  0.00
## annual_avg_wkly_wage             0.01  0.89 0.01  0.21 0.01  0.02  0.00
## avg_annual_pay                   0.01  0.89 0.01  0.21 0.01  0.02  0.00
## lq_annual_avg_estabs             0.00 -0.01 0.00  0.00 0.07  0.00  0.00
## lq_annual_avg_emplvl             0.00  0.02 0.00  0.00 0.97  0.00  0.00
## lq_total_annual_wages            0.00  0.02 0.00  0.00 0.97  0.00  0.00
## lq_annual_avg_wkly_wage          0.01  0.97 0.01  0.02 0.02  0.02 -0.01
## lq_avg_annual_pay                0.01  0.97 0.01  0.02 0.02  0.02 -0.01
## oty_annual_avg_estabs_chg        0.95  0.00 0.00  0.00 0.00  0.00  0.01
## oty_annual_avg_estabs_pct_chg    0.00 -0.01 0.00  0.00 0.00  0.06  1.00
## oty_annual_avg_emplvl_chg        0.99  0.00 0.00  0.00 0.00  0.00  0.00
## oty_annual_avg_emplvl_pct_chg    0.00  0.05 0.02 -0.01 0.00  1.00  0.06
## oty_total_annual_wages_chg       0.99  0.01 0.00  0.00 0.00  0.00  0.00
## oty_total_annual_wages_pct_chg   0.00  0.01 0.93  0.01 0.00  0.06  0.01
## oty_annual_avg_wkly_wage_chg     0.00  0.14 0.02  0.99 0.00 -0.01  0.00
## oty_annual_avg_wkly_wage_pct_chg 0.00  0.01 0.99  0.02 0.00 -0.01  0.00
## oty_avg_annual_pay_chg           0.00  0.14 0.02  0.99 0.00 -0.01  0.00
## oty_avg_annual_pay_pct_chg       0.00  0.01 0.99  0.02 0.00 -0.01  0.00
##                                   RC7   RC9  RC10   h2      u2 com
## annual_avg_estabs                0.00  0.00  0.00 0.99 1.2e-02 1.0
## annual_avg_emplvl                0.00  0.00  0.00 0.98 1.7e-02 1.0
## total_annual_wages               0.00  0.00  0.00 0.98 1.8e-02 1.0
## annual_avg_wkly_wage             0.00  0.41  0.00 1.00 2.4e-06 1.5
## avg_annual_pay                   0.00  0.41  0.00 1.00 2.4e-06 1.5
## lq_annual_avg_estabs             1.00  0.00  0.00 1.00 4.2e-06 1.0
## lq_annual_avg_emplvl             0.03  0.00  0.00 0.95 4.8e-02 1.0
## lq_total_annual_wages            0.04  0.00  0.00 0.95 4.8e-02 1.0
## lq_annual_avg_wkly_wage          0.00 -0.25  0.00 1.00 3.2e-06 1.1
## lq_avg_annual_pay                0.00 -0.25  0.00 1.00 3.2e-06 1.1
## oty_annual_avg_estabs_chg        0.00  0.00  0.00 0.90 9.5e-02 1.0
## oty_annual_avg_estabs_pct_chg    0.00  0.00  0.00 1.00 6.4e-06 1.0
## oty_annual_avg_emplvl_chg        0.00  0.00  0.00 0.98 1.9e-02 1.0
## oty_annual_avg_emplvl_pct_chg    0.00  0.00  0.00 1.00 9.1e-07 1.0
## oty_total_annual_wages_chg       0.00  0.01  0.00 0.98 1.6e-02 1.0
## oty_total_annual_wages_pct_chg   0.00  0.00  0.37 1.00 1.9e-07 1.3
## oty_annual_avg_wkly_wage_chg     0.00  0.02  0.00 1.00 6.0e-07 1.0
## oty_annual_avg_wkly_wage_pct_chg 0.00  0.00 -0.12 1.00 2.7e-06 1.0
## oty_avg_annual_pay_chg           0.00  0.02  0.00 1.00 5.9e-07 1.0
## oty_avg_annual_pay_pct_chg       0.00  0.00 -0.12 1.00 2.7e-06 1.0
##
##                         RC1  RC2  RC3  RC5  RC4  RC8  RC6  RC7  RC9 RC10
## SS loadings           5.82 3.49 2.83 2.05 1.91 1.00 1.00 1.00 0.46 0.17
## Proportion Var        0.29 0.17 0.14 0.10 0.10 0.05 0.05 0.05 0.02 0.01
## Cumulative Var        0.29 0.47 0.61 0.71 0.81 0.86 0.91 0.96 0.98 0.99
## Proportion Explained  0.30 0.18 0.14 0.10 0.10 0.05 0.05 0.05 0.02 0.01
## Cumulative Proportion 0.30 0.47 0.62 0.72 0.82 0.87 0.92 0.97 0.99 1.00
##
## Mean item complexity =  1.1
## Test of the hypothesis that 10 components are sufficient.
##
## The root mean square of the residuals (RMSR) is  0.01
##  with the empirical chi square  36298.7  with prob <  0
##
## Fit based upon off diagonal values = 1
```

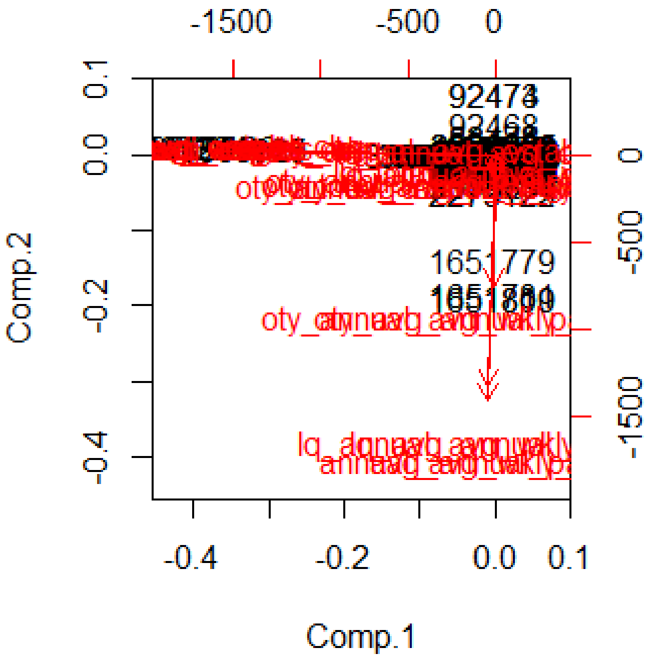
screeplot()

```
screeplot(x=bls.fit.A)
```



biplot()

```
biplot(bls.fit.A)
```



Answers:

[A1] The proportion of the total variation in the data is explained by the summary:

```
summary(bls.fit.A)

## Importance of components:
##                           Comp.1    Comp.2    Comp.3     Comp.4    Comp.5
## Standard deviation     2.4133123 1.9509519 1.6825759 1.38941744 1.3356197
## Proportion of Variance 0.2912038 0.1903107 0.1415531 0.09652404 0.0891940
## Cumulative Proportion  0.2912038 0.4815145 0.6230676 0.71959161 0.8087856
##                            Comp.6     Comp.7     Comp.8     Comp.9
## Standard deviation     1.05473306 0.98658583 0.93864822 0.64982371
## Proportion of Variance 0.05562309 0.04866758 0.04405302 0.02111354
## Cumulative Proportion  0.86440870 0.91307628 0.95712931 0.97824285
##                           Comp.10     Comp.11     Comp.12    Comp.13
## Standard deviation     0.40176237 0.348966740 0.311017829 0.16592286
## Proportion of Variance 0.00807065 0.006088889 0.004836605 0.00137652
## Cumulative Proportion  0.98631350 0.992402387 0.997238992 0.99861551
##                             Comp.14      Comp.15      Comp.16      Comp.17
## Standard deviation     0.1271441265 0.1039242789 2.671013e-02 2.314214e-03
## Proportion of Variance 0.0008082814 0.0005400128 3.567156e-05 2.677792e-07
## Cumulative Proportion  0.9994237932 0.9999638060 9.999995e-01 9.999997e-01
##                             Comp.18      Comp.19      Comp.20
## Standard deviation     2.017410e-03 9.982061e-04 1.649254e-04
## Proportion of Variance 2.034972e-07 4.982077e-08 1.360019e-09
## Cumulative Proportion  9.999999e-01 1.000000e+00 1.000000e+00
```

[A2] The screeplot() shows the variances for each of the components. The component 1 has the highest variance which decreases with each component. Only 10 components are visible out of 20.

[A3] The first 8 components capture about 90% of the variances. Thus I would use the first 8 components. If more variances are to be captured say about 99% then the first 11 components are to be used.

[A4] Yes. There seems to be good amount of clustering as the data seems to be correlated. There is income information in most of the columns. Thus they are related to each other in the data. Hence the data would be similar for most of the columns.

A[5] The biplot for component 1 vs component 2 shows that the data is highly clustered. The cluster is nearer to the origin, showing that more values are either 0 or very close to zero.

A[6] 5 pcs are required to explain 75% variance of the data. The total variance given by the 6 pcs is about 80.8785%