Assignment1

2022-11-11

```
rm(list=ls())

library(psych) #fa()
library(lavaan) #cfa()
```

```
## This is lavaan 0.6-12
## lavaan is FREE software! Please report any bugs.

##
## Attaching package: 'lavaan'

## The following object is masked from 'package:psych':
##
##     cor2cov
```

```
library(MASS)
library(paran) #procedure Horn

#function composite reliability
compositerel<-function(x){
  A<-(sum(x))^2
  B<-sum(1-x^2)
  return(A/(A+B))
}


#load data
load("/Users/yavuzhanyavuz/Desktop/Leuven/Multivariate/cosmetics.Rdata")

#compute centered data
ccosmetics<-cosmetics
ccosmetics[,1:18]<-scale(cosmetics[,1:18],center=TRUE,scale=FALSE)
```

a. Use CFA to construct a measurement model for the Attitude items

```
#step1:confirmatory factor analysis model with 3 correlated latent variables

#measurement model latent variables
cfa1<-' Att_organic=~1*Attitude_organic1+Attitude_organic2+Attitude_organic3
        Att_packaging=~1*Attitude_packaging1+Attitude_packaging2+Attitude_packaging3
        Att_crueltyfree=~1*Attitude_crueltyfree1+Attitude_crueltyfree2+Attitude_crueltyfree3
```

```
        '

#fit model on covariance matrix
fitcfa1<-cfa(cfa1,ccosmetics[,1:9])

#print fitmeasures
fitmeasures(fitcfa1,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##   chisq      df  pvalue     cfi     tli   rmsea    srmr
## 120.886  24.000   0.000   0.889   0.833   0.164   0.057
```

```
#summary of results
summary(fitcfa1,fit.measures=TRUE)
```

```
## lavaan 0.6-12 ended normally after 31 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        21
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               120.886
##   Degrees of freedom                                24
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                               906.005
##   Degrees of freedom                                36
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.889
##   Tucker-Lewis Index (TLI)                       0.833
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -1456.006
##   Loglikelihood unrestricted model (H1)      -1395.564
##
##   Akaike (AIC)                                2954.013
##   Bayesian (BIC)                              3017.236
##   Sample-size adjusted Bayesian (BIC)         2950.775
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.164
##   90 Percent confidence interval - lower         0.136
##   90 Percent confidence interval - upper         0.194
```

```
##   P-value RMSEA <= 0.05                          0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.057
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                     Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic =~
##     Attitude_rgnc1      1.000
##     Attitude_rgnc2      0.835    0.090    9.231    0.000
##     Attitude_rgnc3      1.040    0.114    9.116    0.000
##   Att_packaging =~
##     Attitd_pckgng1      1.000
##     Attitd_pckgng2      0.855    0.079   10.822    0.000
##     Attitd_pckgng3      1.144    0.104   10.972    0.000
##   Att_crueltyfree =~
##     Atttd_crltyfr1      1.000
##     Atttd_crltyfr2      0.937    0.076   12.288    0.000
##     Atttd_crltyfr3      1.128    0.079   14.194    0.000
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic ~~
##     Att_packaging     0.414    0.068    6.081    0.000
##     Att_crueltyfre    0.374    0.068    5.510    0.000
##   Att_packaging ~~
##     Att_crueltyfre    0.475    0.077    6.198    0.000
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##    .Attitude_rgnc1    0.168    0.041    4.099    0.000
##    .Attitude_rgnc2    0.332    0.048    6.974    0.000
##    .Attitude_rgnc3    0.540    0.076    7.060    0.000
##    .Attitd_pckgng1    0.242    0.042    5.712    0.000
##    .Attitd_pckgng2    0.252    0.038    6.605    0.000
##    .Attitd_pckgng3    0.425    0.066    6.469    0.000
##    .Atttd_crltyfr1    0.145    0.035    4.196    0.000
##    .Atttd_crltyfr2    0.382    0.053    7.185    0.000
##    .Atttd_crltyfr3    0.313    0.054    5.837    0.000
##     Att_organic       0.531    0.086    6.150    0.000
##     Att_packaging     0.592    0.097    6.071    0.000
##     Att_crueltyfre    0.725    0.104    7.001    0.000
```

```
#print standardized solution
standardizedSolution(fitcfa1)
```

```
##                     lhs op                  rhs est.std    se      z pvalue
```

```
## 1            Att_organic =~     Attitude_organic1   0.871 0.036 24.461      0
## 2            Att_organic =~     Attitude_organic2   0.726 0.048 15.272      0
## 3            Att_organic =~     Attitude_organic3   0.718 0.048 14.856      0
## 4          Att_packaging =~   Attitude_packaging1   0.843 0.033 25.698      0
## 5          Att_packaging =~   Attitude_packaging2   0.795 0.038 21.079      0
## 6          Att_packaging =~   Attitude_packaging3   0.803 0.037 21.861      0
## 7        Att_crueltyfree =~ Attitude_crueltyfree1   0.913 0.023 39.019      0
## 8        Att_crueltyfree =~ Attitude_crueltyfree2   0.790 0.036 22.100      0
## 9        Att_crueltyfree =~ Attitude_crueltyfree3   0.864 0.028 31.121      0
## 10     Attitude_organic1 ~~     Attitude_organic1   0.241 0.062  3.880      0
## 11     Attitude_organic2 ~~     Attitude_organic2   0.473 0.069  6.855      0
## 12     Attitude_organic3 ~~     Attitude_organic3   0.485 0.069  6.990      0
## 13   Attitude_packaging1 ~~   Attitude_packaging1   0.290 0.055  5.252      0
## 14   Attitude_packaging2 ~~   Attitude_packaging2   0.369 0.060  6.151      0
## 15   Attitude_packaging3 ~~   Attitude_packaging3   0.354 0.059  6.000      0
## 16 Attitude_crueltyfree1 ~~ Attitude_crueltyfree1   0.167 0.043  3.901      0
## 17 Attitude_crueltyfree2 ~~ Attitude_crueltyfree2   0.375 0.057  6.638      0
## 18 Attitude_crueltyfree3 ~~ Attitude_crueltyfree3   0.253 0.048  5.275      0
## 19           Att_organic ~~           Att_organic   1.000 0.000     NA     NA
## 20         Att_packaging ~~         Att_packaging   1.000 0.000     NA     NA
## 21       Att_crueltyfree ~~       Att_crueltyfree   1.000 0.000     NA     NA
## 22           Att_organic ~~         Att_packaging   0.739 0.054 13.756      0
## 23           Att_organic ~~       Att_crueltyfree   0.603 0.065  9.311      0
## 24         Att_packaging ~~       Att_crueltyfree   0.725 0.051 14.242      0
##    ci.lower ci.upper
## 1     0.801    0.941
## 2     0.633    0.819
## 3     0.623    0.812
## 4     0.778    0.907
## 5     0.721    0.869
## 6     0.731    0.876
## 7     0.867    0.959
## 8     0.720    0.860
## 9     0.810    0.919
## 10    0.119    0.362
## 11    0.338    0.608
## 12    0.349    0.621
## 13    0.182    0.398
## 14    0.251    0.486
## 15    0.239    0.470
## 16    0.083    0.250
## 17    0.264    0.486
## 18    0.159    0.347
## 19    1.000    1.000
## 20    1.000    1.000
## 21    1.000    1.000
## 22    0.634    0.845
## 23    0.476    0.730
## 24    0.625    0.825
```

```
#reliability factor scores
d<-standardizedSolution(fitcfa1)
#composite reliability attitude_organic
compositerel(d[1:3,4])
```

```
## [1] 0.8172124
```

```
#composite reliability attitude_packaging
compositerel(d[4:6,4])
```

```
## [1] 0.8546459
```

```
#composite reliability attitude_crueltyfree
compositerel(d[7:9,4])
```

```
## [1] 0.892363
```

```
#overview table composite reliability
factorscore<-c("attitude_organic","attitude_packaging","attitude_crueltyfree")
reliability<-round(c(compositerel(d[1:3,4]),compositerel(d[4:6,4]),compositerel(d[7:9,4])),3)
data.frame(factorscore,reliability)
```

```
##            factorscore reliability
## 1     attitude_organic       0.817
## 2   attitude_packaging       0.855
## 3 attitude_crueltyfree       0.892
```

```
## step2: correlated error terms for variables measured using the same method #!
cfa2<-' Att_organic=~1*Attitude_organic1+Attitude_organic2+Attitude_organic3
        Att_packaging=~1*Attitude_packaging1+Attitude_packaging2+Attitude_packaging3
        Att_crueltyfree=~1*Attitude_crueltyfree1+Attitude_crueltyfree2+Attitude_crueltyfree3

        Att_organic ~~1*Att_organic
        Att_packaging ~~ 1*Att_packaging
        Att_crueltyfree ~~1*Att_crueltyfree

        Att_organic ~~ Att_packaging
        Att_packaging ~~ Att_crueltyfree
        Att_organic ~~ Att_crueltyfree

        Attitude_organic1~~a*Attitude_packaging1
        Attitude_organic1~~a*Attitude_crueltyfree1
        Attitude_packaging1~~a*Attitude_crueltyfree1

        Attitude_organic2~~b*Attitude_packaging2
        Attitude_organic2~~b*Attitude_crueltyfree2
        Attitude_packaging2~~b*Attitude_crueltyfree2

        Attitude_organic3~~c*Attitude_packaging3
        Attitude_organic3~~c*Attitude_crueltyfree3
        Attitude_packaging3~~c*Attitude_crueltyfree3
        '
#fit model on covariance matrix
fitcfa2<-cfa(cfa2,ccosmetics)

#print fitmeasures
fitmeasures(fitcfa2,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##  chisq     df pvalue    cfi    tli  rmsea   srmr
## 74.102 24.000  0.000  0.942  0.914  0.118  0.296
```

```
#summary of results
summary(fitcfa2,fit.measures=TRUE)
```

```
## lavaan 0.6-12 ended normally after 30 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        27
##   Number of equality constraints                     6
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                                74.102
##   Degrees of freedom                                24
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                               906.005
##   Degrees of freedom                                36
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.942
##   Tucker-Lewis Index (TLI)                       0.914
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -1432.615
##   Loglikelihood unrestricted model (H1)      -1395.564
##
##   Akaike (AIC)                                2907.229
##   Bayesian (BIC)                              2970.453
##   Sample-size adjusted Bayesian (BIC)         2903.992
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.118
##   90 Percent confidence interval - lower         0.088
##   90 Percent confidence interval - upper         0.149
##   P-value RMSEA <= 0.05                          0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.296
##
## Parameter Estimates:
##
```

```
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                     Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic =~
##     Attitude_rgnc1      1.000
##     Attitude_rgnc2      0.750    0.058   13.013    0.000
##     Attitude_rgnc3      0.873    0.069   12.682    0.000
##   Att_packaging =~
##     Attitd_pckgng1      1.000
##     Attitd_pckgng2      0.773    0.051   15.193    0.000
##     Attitd_pckgng3      1.032    0.068   15.245    0.000
##   Att_crueltyfree =~
##     Atttd_crltyfr1      1.000
##     Atttd_crltyfr2      0.874    0.062   14.210    0.000
##     Atttd_crltyfr3      1.073    0.065   16.400    0.000
##
## Covariances:
##                       Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic ~~
##     Att_pckgng             0.778    0.036   21.538    0.000
##   Att_packaging ~~
##     Att_crltyf             0.767    0.036   21.230    0.000
##   Att_organic ~~
##     Att_crltyf             0.670    0.046   14.489    0.000
##  .Attitude_organic1 ~~
##    .Atttd_pck1 (a)        -0.008    0.024   -0.313    0.754
##    .Atttd_crl1 (a)        -0.008    0.024   -0.313    0.754
##  .Attitude_packaging1 ~~
##    .Atttd_crl1 (a)        -0.008    0.024   -0.313    0.754
##  .Attitude_organic2 ~~
##    .Atttd_pck2 (b)         0.117    0.028    4.263    0.000
##    .Atttd_crl2 (b)         0.117    0.028    4.263    0.000
##  .Attitude_packaging2 ~~
##    .Atttd_crl2 (b)         0.117    0.028    4.263    0.000
##  .Attitude_organic3 ~~
##    .Atttd_pck3 (c)         0.168    0.040    4.196    0.000
##    .Atttd_crl3 (c)         0.168    0.040    4.196    0.000
##  .Attitude_packaging3 ~~
##    .Atttd_crl3 (c)         0.168    0.040    4.196    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##     Att_organic       1.000
##     Att_packaging     1.000
##     Att_crueltyfre    1.000
##    .Attitude_rgnc1    0.100    0.046    2.174    0.030
##    .Attitude_rgnc2    0.359    0.047    7.585    0.000
##    .Attitude_rgnc3    0.528    0.068    7.750    0.000
##    .Attitd_pckgng1    0.179    0.044    4.053    0.000
##    .Attitd_pckgng2    0.262    0.038    6.966    0.000
##    .Attitd_pckgng3    0.461    0.065    7.078    0.000
```

```
##    .Atttd_crltyfr1    0.106    0.039    2.710    0.007
##    .Atttd_crltyfr2    0.426    0.055    7.806    0.000
##    .Atttd_crltyfr3    0.416    0.062    6.649    0.000
```

```
lavInspect(fitcfa2, "cor.lv")
```

```
##                 Att_rg Att_pc Att_cr
## Att_organic     1.000
## Att_packaging   0.778  1.000
## Att_crueltyfree 0.670  0.767  1.000
```

```
#print standardized solution
standardizedSolution(fitcfa2)
```

```
##                      lhs op                   rhs label est.std    se      z
## 1            Att_organic =~     Attitude_organic1         0.954 0.020 47.990
## 2            Att_organic =~     Attitude_organic2         0.781 0.034 22.724
## 3            Att_organic =~     Attitude_organic3         0.769 0.035 21.675
## 4          Att_packaging =~   Attitude_packaging1         0.921 0.017 53.420
## 5          Att_packaging =~   Attitude_packaging2         0.834 0.028 30.125
## 6          Att_packaging =~   Attitude_packaging3         0.835 0.027 30.724
## 7        Att_crueltyfree =~ Attitude_crueltyfree1         0.951 0.017 56.641
## 8        Att_crueltyfree =~ Attitude_crueltyfree2         0.801 0.030 26.788
## 9        Att_crueltyfree =~ Attitude_crueltyfree3         0.857 0.025 34.016
## 10           Att_organic ~~           Att_organic         1.000 0.000     NA
## 11         Att_packaging ~~         Att_packaging         1.000 0.000     NA
## 12       Att_crueltyfree ~~       Att_crueltyfree         1.000 0.000     NA
## 13           Att_organic ~~         Att_packaging         0.778 0.036 21.538
## 14         Att_packaging ~~       Att_crueltyfree         0.767 0.036 21.230
## 15           Att_organic ~~       Att_crueltyfree         0.670 0.046 14.489
## 16     Attitude_organic1 ~~   Attitude_packaging1     a  -0.057 0.191 -0.296
## 17     Attitude_organic1 ~~ Attitude_crueltyfree1     a  -0.074 0.251 -0.293
## 18   Attitude_packaging1 ~~ Attitude_crueltyfree1     a  -0.055 0.184 -0.298
## 19     Attitude_organic2 ~~   Attitude_packaging2     b   0.382 0.069  5.551
## 20     Attitude_organic2 ~~ Attitude_crueltyfree2     b   0.300 0.057  5.222
## 21   Attitude_packaging2 ~~ Attitude_crueltyfree2     b   0.351 0.065  5.411
## 22     Attitude_organic3 ~~   Attitude_packaging3     c   0.340 0.064  5.304
## 23     Attitude_organic3 ~~ Attitude_crueltyfree3     c   0.358 0.067  5.375
## 24   Attitude_packaging3 ~~ Attitude_crueltyfree3     c   0.383 0.070  5.493
## 25     Attitude_organic1 ~~     Attitude_organic1         0.091 0.038  2.391
## 26     Attitude_organic2 ~~     Attitude_organic2         0.390 0.054  7.251
## 27     Attitude_organic3 ~~     Attitude_organic3         0.409 0.055  7.505
## 28   Attitude_packaging1 ~~   Attitude_packaging1         0.152 0.032  4.778
## 29   Attitude_packaging2 ~~   Attitude_packaging2         0.305 0.046  6.606
## 30   Attitude_packaging3 ~~   Attitude_packaging3         0.302 0.045  6.647
## 31 Attitude_crueltyfree1 ~~ Attitude_crueltyfree1         0.096 0.032  2.997
## 32 Attitude_crueltyfree2 ~~ Attitude_crueltyfree2         0.358 0.048  7.460
## 33 Attitude_crueltyfree3 ~~ Attitude_crueltyfree3         0.265 0.043  6.143
##    pvalue ci.lower ci.upper
## 1   0.000    0.915    0.993
## 2   0.000    0.714    0.849
## 3   0.000    0.699    0.838
## 4   0.000    0.887    0.955
```

```
## 5   0.000    0.779    0.888
## 6   0.000    0.782    0.889
## 7   0.000    0.918    0.984
## 8   0.000    0.743    0.860
## 9   0.000    0.808    0.907
## 10     NA    1.000    1.000
## 11     NA    1.000    1.000
## 12     NA    1.000    1.000
## 13  0.000    0.708    0.849
## 14  0.000    0.697    0.838
## 15  0.000    0.579    0.761
## 16  0.767   -0.431    0.318
## 17  0.769   -0.565    0.418
## 18  0.765   -0.416    0.306
## 19  0.000    0.247    0.517
## 20  0.000    0.188    0.413
## 21  0.000    0.224    0.478
## 22  0.000    0.214    0.465
## 23  0.000    0.227    0.488
## 24  0.000    0.246    0.519
## 25  0.017    0.016    0.165
## 26  0.000    0.284    0.495
## 27  0.000    0.302    0.516
## 28  0.000    0.090    0.214
## 29  0.000    0.214    0.395
## 30  0.000    0.213    0.391
## 31  0.003    0.033    0.158
## 32  0.000    0.264    0.452
## 33  0.000    0.181    0.350
```

b. Use CFA to construct a measurement model for the Behavior-Intention items

After loading the data, we compute centered variables. We fit a CFA model with 3 correlated latent variables for the and print fit measures and the standardized solution.

```
#step1:confirmatory factor analysis model with 3 correlated latent variables
cfa3<-' BI_organic=~1*BI_organic1+BI_organic2+BI_organic3
        BI_packaging=~1*BI_packaging1+BI_packaging2+BI_packaging3
        BI_crueltyfree=~1*BI_crueltyfree1+BI_crueltyfree2+BI_crueltyfree3
        '

#fit model on covariance matrix
fitcfa3<-cfa(cfa3,ccosmetics)

#print fitmeasures
fitmeasures(fitcfa3,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##   chisq      df  pvalue     cfi     tli   rmsea    srmr
## 147.814  24.000   0.000   0.914   0.871   0.185   0.033
```

```
#summary of results
summary(fitcfa3,fit.measures=TRUE)
```

```
## lavaan 0.6-12 ended normally after 42 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        21
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               147.814
##   Degrees of freedom                                24
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                              1478.427
##   Degrees of freedom                                36
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.914
##   Tucker-Lewis Index (TLI)                       0.871
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -1321.972
##   Loglikelihood unrestricted model (H1)      -1248.065
##
##   Akaike (AIC)                                2685.945
##   Bayesian (BIC)                              2749.168
##   Sample-size adjusted Bayesian (BIC)         2682.707
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.185
##   90 Percent confidence interval - lower         0.157
##   90 Percent confidence interval - upper         0.215
##   P-value RMSEA <= 0.05                          0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.033
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic =~
```

```
##     BI_organic1        1.000
##     BI_organic2        0.968    0.062   15.584    0.000
##     BI_organic3        0.918    0.066   13.854    0.000
##   BI_packaging =~
##     BI_packaging1      1.000
##     BI_packaging2      1.012    0.067   15.218    0.000
##     BI_packaging3      0.955    0.066   14.398    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1     1.000
##     BI_crueltyfre2     0.999    0.053   18.896    0.000
##     BI_crueltyfre3     0.984    0.049   20.114    0.000
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~~
##     BI_packaging      0.745    0.106    7.052    0.000
##     BI_crueltyfree    0.770    0.113    6.800    0.000
##   BI_packaging ~~
##     BI_crueltyfree    0.772    0.110    6.999    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .BI_organic1       0.247    0.041    6.081    0.000
##    .BI_organic2       0.206    0.036    5.754    0.000
##    .BI_organic3       0.310    0.045    6.955    0.000
##    .BI_packaging1     0.245    0.038    6.509    0.000
##    .BI_packaging2     0.213    0.035    6.106    0.000
##    .BI_packaging3     0.245    0.037    6.699    0.000
##    .BI_crueltyfre1    0.206    0.033    6.240    0.000
##    .BI_crueltyfre2    0.200    0.032    6.175    0.000
##    .BI_crueltyfre3    0.139    0.027    5.203    0.000
##     BI_organic        0.901    0.133    6.790    0.000
##     BI_packaging      0.804    0.120    6.678    0.000
##     BI_crueltyfree    1.070    0.147    7.270    0.000
```

```
#print standardized solution
standardizedSolution(fitcfa3)
```

```
##                lhs op             rhs est.std    se      z pvalue ci.lower
## 1       BI_organic =~     BI_organic1   0.886 0.023 39.149      0    0.841
## 2       BI_organic =~     BI_organic2   0.897 0.021 41.980      0    0.855
## 3       BI_organic =~     BI_organic3   0.843 0.028 30.204      0    0.788
## 4     BI_packaging =~   BI_packaging1   0.875 0.023 37.407      0    0.829
## 5     BI_packaging =~   BI_packaging2   0.892 0.021 41.621      0    0.850
## 6     BI_packaging =~   BI_packaging3   0.866 0.025 35.243      0    0.818
## 7   BI_crueltyfree =~ BI_crueltyfree1   0.916 0.016 55.816      0    0.884
## 8   BI_crueltyfree =~ BI_crueltyfree2   0.918 0.016 56.707      0    0.886
## 9   BI_crueltyfree =~ BI_crueltyfree3   0.939 0.014 68.618      0    0.912
## 10     BI_organic1 ~~     BI_organic1   0.215 0.040  5.374      0    0.137
## 11     BI_organic2 ~~     BI_organic2   0.196 0.038  5.109      0    0.121
## 12     BI_organic3 ~~     BI_organic3   0.290 0.047  6.169      0    0.198
## 13   BI_packaging1 ~~   BI_packaging1   0.234 0.041  5.707      0    0.154
## 14   BI_packaging2 ~~   BI_packaging2   0.205 0.038  5.370      0    0.130
## 15   BI_packaging3 ~~   BI_packaging3   0.250 0.043  5.877      0    0.167
```

```
## 16 BI_crueltyfree1 ~~ BI_crueltyfree1   0.161 0.030  5.367      0    0.102
## 17 BI_crueltyfree2 ~~ BI_crueltyfree2   0.158 0.030  5.319      0    0.100
## 18 BI_crueltyfree3 ~~ BI_crueltyfree3   0.118 0.026  4.607      0    0.068
## 19      BI_organic ~~      BI_organic   1.000 0.000     NA     NA    1.000
## 20    BI_packaging ~~    BI_packaging   1.000 0.000     NA     NA    1.000
## 21  BI_crueltyfree ~~  BI_crueltyfree   1.000 0.000     NA     NA    1.000
## 22      BI_organic ~~    BI_packaging   0.876 0.028 30.822      0    0.820
## 23      BI_organic ~~  BI_crueltyfree   0.784 0.038 20.551      0    0.710
## 24    BI_packaging ~~  BI_crueltyfree   0.832 0.032 25.983      0    0.770
##    ci.upper
## 1     0.930
## 2     0.939
## 3     0.897
## 4     0.921
## 5     0.934
## 6     0.914
## 7     0.948
## 8     0.949
## 9     0.966
## 10    0.294
## 11    0.271
## 12    0.382
## 13    0.314
## 14    0.280
## 15    0.334
## 16    0.220
## 17    0.216
## 18    0.169
## 19    1.000
## 20    1.000
## 21    1.000
## 22    0.932
## 23    0.859
## 24    0.895
```

The **fit measures** indicate that the model is rejected by an absolute goodness of fit test, i.e. the fit of the model is significantly lower than for a perfectly fitting model (chi-square=147.8, df=24, p<.001). Descriptive fit measures indicate that the model does not fit the covariance matrix well: CFI (.914) and TLI (.871) both below the cutoff of .95 which indicates good fit. In addition, RMSEA (.185) and SRMR (.033) so that the cutoff value for good model fit(cutoff<.08) is only satisfied for SRMR. Given these results, further modifications to the model are needed.

Factor correlations:From the covariances matrix, we can see the factors have positive significant correlations.

As can be seen in the standardized solution, all variables have significant and positive standardized loadings that exceed 0.7. Hence, the variables have sufficient reliability so that **convergent validity** is satisfied for the measurement model. Furthermore, **divergent validity** is also satisfied as all latent variables have moderate correlations that are significantly smaller than 1.

Finally, the composite reliability of all the factor scores is good as it exceeds .80.

```
#reliability factor scores
d<-standardizedSolution(fitcfa3)
#composite reliability BI_organic
compositerel(d[1:3,4])
```

```
## [1] 0.9076501
```

```
#composite reliability BI_packaging
compositerel(d[4:6,4])
```

```
## [1] 0.9095885
```

```
#composite reliability BI_crueltyfree
compositerel(d[7:9,4])
```

```
## [1] 0.9461286
```

```
#overview table composite reliability
factorscore<-c("BI_organic","BI_packaging","BI_crueltyfree")
reliability<-round(c(compositerel(d[1:3,4]),compositerel(d[4:6,4]),compositerel(d[7:9,4])),3)
data.frame(factorscore,reliability)
```

```
##      factorscore reliability
## 1     BI_organic       0.908
## 2   BI_packaging       0.910
## 3 BI_crueltyfree       0.946
```

Next we extend the CFA model by including correlated error terms, which we imposed the constraint of equal residual correlations, for all pairs of items that focus on the same aspect.

```
## step2: correlated error terms for variables measured using the same method
cfa4<-' BI_organic=~1*BI_organic1+BI_organic2+BI_organic3
        BI_packaging=~1*BI_packaging1+BI_packaging2+BI_packaging3
        BI_crueltyfree=~1*BI_crueltyfree1+BI_crueltyfree2+BI_crueltyfree3

        BI_organic ~~1*BI_organic
        BI_packaging ~~ 1*BI_packaging
        BI_crueltyfree ~~1*BI_crueltyfree

        BI_organic ~~ BI_packaging
        BI_packaging ~~ BI_crueltyfree
        BI_organic ~~ BI_crueltyfree

        BI_organic1~~a*BI_packaging1
        BI_organic1~~a*BI_crueltyfree1
        BI_packaging1~~a*BI_crueltyfree1

        BI_organic2~~b*BI_packaging2
        BI_organic2~~b*BI_crueltyfree2
        BI_packaging2~~b*BI_crueltyfree2

        BI_organic3~~c*BI_packaging3
        BI_organic3~~c*BI_crueltyfree3
        BI_packaging3~~c*BI_crueltyfree3
        '
#fit model on covariance matrix
```

```r
fitcfa4<-cfa(cfa4,ccosmetics[,10:18])

#print fitmeasures
fitmeasures(fitcfa4,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##  chisq     df pvalue    cfi    tli  rmsea   srmr
## 31.251 24.000  0.147  0.995  0.992  0.045  0.074
```

```r
#summary of results
summary(fitcfa4,fit.measures=TRUE)
```

```
## lavaan 0.6-12 ended normally after 36 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        27
##   Number of equality constraints                     6
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                                31.251
##   Degrees of freedom                                24
##   P-value (Chi-square)                           0.147
##
## Model Test Baseline Model:
##
##   Test statistic                              1478.427
##   Degrees of freedom                                36
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.995
##   Tucker-Lewis Index (TLI)                       0.992
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -1263.691
##   Loglikelihood unrestricted model (H1)      -1248.065
##
##   Akaike (AIC)                                2569.381
##   Bayesian (BIC)                              2632.605
##   Sample-size adjusted Bayesian (BIC)         2566.144
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.045
##   90 Percent confidence interval - lower         0.000
##   90 Percent confidence interval - upper         0.085
##   P-value RMSEA <= 0.05                          0.542
```

```
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.074
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                     Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic =~
##     BI_organic1        1.000
##     BI_organic2        0.949    0.052   18.281    0.000
##     BI_organic3        0.905    0.055   16.449    0.000
##   BI_packaging =~
##     BI_packaging1      1.000
##     BI_packaging2      0.965    0.050   19.309    0.000
##     BI_packaging3      0.896    0.053   16.911    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1     1.000
##     BI_crueltyfre2     1.012    0.048   21.025    0.000
##     BI_crueltyfre3     1.001    0.044   22.530    0.000
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~~
##     BI_packgng        0.853    0.024   34.878    0.000
##   BI_packaging ~~
##     BI_crltyfr        0.809    0.028   28.911    0.000
##   BI_organic ~~
##     BI_crltyfr        0.761    0.034   22.617    0.000
##  .BI_organic1 ~~
##    .BI_pckgng1 (a)    0.077    0.024    3.225    0.001
##    .BI_crltyf1 (a)    0.077    0.024    3.225    0.001
##  .BI_packaging1 ~~
##    .BI_crltyf1 (a)    0.077    0.024    3.225    0.001
##  .BI_organic2 ~~
##    .BI_pckgng2 (b)    0.112    0.025    4.540    0.000
##    .BI_crltyf2 (b)    0.112    0.025    4.540    0.000
##  .BI_packaging2 ~~
##    .BI_crltyf2 (b)    0.112    0.025    4.540    0.000
##  .BI_organic3 ~~
##    .BI_pckgng3 (c)    0.061    0.021    2.860    0.004
##    .BI_crltyf3 (c)    0.061    0.021    2.860    0.004
##  .BI_packaging3 ~~
##    .BI_crltyf3 (c)    0.061    0.021    2.860    0.004
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##    BI_organic         1.000
##    BI_packaging       1.000
```

```
##     BI_crueltyfree    1.000
##    .BI_organic1       0.248    0.041    6.036    0.000
##    .BI_organic2       0.233    0.037    6.279    0.000
##    .BI_organic3       0.285    0.042    6.807    0.000
##    .BI_packaging1     0.239    0.039    6.144    0.000
##    .BI_packaging2     0.210    0.035    6.047    0.000
##    .BI_packaging3     0.266    0.039    6.864    0.000
##    .BI_crueltyfre1    0.198    0.032    6.235    0.000
##    .BI_crueltyfre2    0.205    0.032    6.408    0.000
##    .BI_crueltyfre3    0.134    0.027    4.864    0.000
```

```
#print standardized solution
standardizedSolution(fitcfa4)
```

```
##                lhs op             rhs label est.std    se      z pvalue
## 1       BI_organic =~     BI_organic1         0.895 0.015 60.744  0.000
## 2       BI_organic =~     BI_organic2         0.891 0.020 45.170  0.000
## 3       BI_organic =~     BI_organic3         0.861 0.023 36.978  0.000
## 4     BI_packaging =~   BI_packaging1         0.899 0.014 63.798  0.000
## 5     BI_packaging =~   BI_packaging2         0.903 0.018 50.279  0.000
## 6     BI_packaging =~   BI_packaging3         0.866 0.022 39.131  0.000
## 7   BI_crueltyfree =~ BI_crueltyfree1         0.914 0.012 75.527  0.000
## 8   BI_crueltyfree =~ BI_crueltyfree2         0.913 0.015 60.793  0.000
## 9   BI_crueltyfree =~ BI_crueltyfree3         0.939 0.014 69.386  0.000
## 10      BI_organic ~~      BI_organic         1.000 0.000     NA     NA
## 11    BI_packaging ~~    BI_packaging         1.000 0.000     NA     NA
## 12  BI_crueltyfree ~~  BI_crueltyfree         1.000 0.000     NA     NA
## 13      BI_organic ~~    BI_packaging         0.853 0.024 34.878  0.000
## 14    BI_packaging ~~  BI_crueltyfree         0.809 0.028 28.911  0.000
## 15      BI_organic ~~  BI_crueltyfree         0.761 0.034 22.617  0.000
## 16     BI_organic1 ~~   BI_packaging1     a   0.316 0.076  4.152  0.000
## 17     BI_organic1 ~~ BI_crueltyfree1     a   0.347 0.082  4.216  0.000
## 18   BI_packaging1 ~~ BI_crueltyfree1     a   0.353 0.083  4.259  0.000
## 19     BI_organic2 ~~   BI_packaging2     b   0.505 0.071  7.076  0.000
## 20     BI_organic2 ~~ BI_crueltyfree2     b   0.512 0.072  7.060  0.000
## 21   BI_packaging2 ~~ BI_crueltyfree2     b   0.539 0.073  7.352  0.000
## 22     BI_organic3 ~~   BI_packaging3     c   0.221 0.065  3.392  0.001
## 23     BI_organic3 ~~ BI_crueltyfree3     c   0.311 0.085  3.644  0.000
## 24   BI_packaging3 ~~ BI_crueltyfree3     c   0.322 0.087  3.679  0.000
## 25     BI_organic1 ~~     BI_organic1         0.199 0.026  7.533  0.000
## 26     BI_organic2 ~~     BI_organic2         0.205 0.035  5.839  0.000
## 27     BI_organic3 ~~     BI_organic3         0.258 0.040  6.427  0.000
## 28   BI_packaging1 ~~   BI_packaging1         0.193 0.025  7.610  0.000
## 29   BI_packaging2 ~~   BI_packaging2         0.184 0.032  5.668  0.000
## 30   BI_packaging3 ~~   BI_packaging3         0.249 0.038  6.496  0.000
## 31 BI_crueltyfree1 ~~ BI_crueltyfree1         0.165 0.022  7.467  0.000
## 32 BI_crueltyfree2 ~~ BI_crueltyfree2         0.166 0.027  6.068  0.000
## 33 BI_crueltyfree3 ~~ BI_crueltyfree3         0.118 0.025  4.627  0.000
##    ci.lower ci.upper
## 1     0.866    0.924
## 2     0.853    0.930
## 3     0.816    0.907
## 4     0.871    0.926
## 5     0.868    0.939
```

```
## 6     0.823    0.910
## 7     0.890    0.937
## 8     0.884    0.942
## 9     0.913    0.966
## 10    1.000    1.000
## 11    1.000    1.000
## 12    1.000    1.000
## 13    0.805    0.900
## 14    0.754    0.863
## 15    0.695    0.827
## 16    0.167    0.465
## 17    0.185    0.508
## 18    0.191    0.516
## 19    0.365    0.645
## 20    0.370    0.654
## 21    0.395    0.683
## 22    0.093    0.348
## 23    0.144    0.479
## 24    0.150    0.493
## 25    0.147    0.250
## 26    0.136    0.274
## 27    0.179    0.337
## 28    0.143    0.242
## 29    0.120    0.248
## 30    0.174    0.324
## 31    0.122    0.208
## 32    0.113    0.220
## 33    0.068    0.168
```

The **fit measures** of the extended CFA model indicate that the model fits the data well(chi-square=31.251, df=24, p=.147) and has excellent descriptive goodness of fit.CFI=.995 and TLI=.992 both exceed the cutoff of .95 which indicates good fit, RMSEA (.045) and SRMR (.074) also indicate a good fit as they are well below the cutoff of .08. Given the results, the fit measures of the CFA models fitted in the second step is much better than the first step.

The results of the correlated error model indicate that items focus on the same aspect have significant positive **residual correlations**. i.e. for "making an effort to buy", the residual correlation is around .33; for "recommending", the residual correlation is around 0.51; for "checking the sustainable label", the residual correlation is between .22-.32.

c.Build a structural equation model to evaluate the impact of attitude on behavior intention

#We use the **sem()** function to fit the structural equation model on the covariance matrix, and print fit measures and model output (including the standardized solution).

```
##first step
sem1 <-'# measurement model
        Att_organic=~Attitude_organic1+Attitude_organic2+Attitude_organic3
        Att_packaging=~Attitude_packaging1+Attitude_packaging2+Attitude_packaging3
        Att_crueltyfree=~Attitude_crueltyfree1+Attitude_crueltyfree2+Attitude_crueltyfree3
        BI_organic=~1*BI_organic1+BI_organic2+BI_organic3
        BI_packaging=~1*BI_packaging1+BI_packaging2+BI_packaging3
```

```
        BI_crueltyfree=~1*BI_crueltyfree1+BI_crueltyfree2+BI_crueltyfree3

        # structural model(regressions)
        BI_organic~Att_organic
        BI_packaging~Att_packaging
        BI_crueltyfree~Att_crueltyfree

        #variance latent variables
        Att_organic~~Att_organic
        Att_packaging~~Att_packaging
        Att_crueltyfree~~Att_crueltyfree
        BI_organic~~1*BI_organic
        BI_packaging~~1*BI_packaging
        BI_crueltyfree~~1*BI_crueltyfree'

fitsem1 <- sem(sem1, data =ccosmetics)
summary(fitsem1, fit.measure = TRUE)
```

```
## lavaan 0.6-12 ended normally after 62 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        42
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               389.013
##   Degrees of freedom                               129
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                              2667.493
##   Degrees of freedom                               153
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.897
##   Tucker-Lewis Index (TLI)                       0.877
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2696.605
##   Loglikelihood unrestricted model (H1)      -2502.099
##
##   Akaike (AIC)                                5477.211
##   Bayesian (BIC)                              5603.657
##   Sample-size adjusted Bayesian (BIC)         5470.735
##
## Root Mean Square Error of Approximation:
```

```
##
##   RMSEA                                          0.116
##   90 Percent confidence interval - lower         0.103
##   90 Percent confidence interval - upper         0.129
##   P-value RMSEA <= 0.05                          0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.195
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                      Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic =~
##     Attitude_rgnc1      1.000
##     Attitude_rgnc2      0.850    0.089    9.575    0.000
##     Attitude_rgnc3      1.084    0.111    9.734    0.000
##   Att_packaging =~
##     Attitd_pckgng1      1.000
##     Attitd_pckgng2      0.850    0.078   10.906    0.000
##     Attitd_pckgng3      1.176    0.101   11.599    0.000
##   Att_crueltyfree =~
##     Atttd_crltyfr1      1.000
##     Atttd_crltyfr2      0.968    0.076   12.697    0.000
##     Atttd_crltyfr3      1.164    0.078   14.897    0.000
##   BI_organic =~
##     BI_organic1         1.000
##     BI_organic2         0.939    0.041   22.917    0.000
##     BI_organic3         0.884    0.046   19.028    0.000
##   BI_packaging =~
##     BI_packaging1       1.000
##     BI_packaging2       0.949    0.040   23.508    0.000
##     BI_packaging3       0.878    0.043   20.433    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1      1.000
##     BI_crueltyfre2      0.963    0.039   24.715    0.000
##     BI_crueltyfre3      0.944    0.036   26.501    0.000
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~
##     Att_organic       0.901    0.106    8.465    0.000
##   BI_packaging ~
##     Att_packaging     0.804    0.093    8.638    0.000
##   BI_crueltyfree ~
##     Att_crueltyfre    0.833    0.082   10.180    0.000
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)
```

```
##   Att_organic ~~
##     Att_packaging     0.416    0.067    6.222    0.000
##     Att_crueltyfre    0.382    0.067    5.750    0.000
##   Att_packaging ~~
##     Att_crueltyfre    0.457    0.074    6.162    0.000
##  .BI_organic ~~
##    .BI_packaging      0.967    0.021   46.595    0.000
##    .BI_crueltyfree    0.910    0.026   34.785    0.000
##  .BI_packaging ~~
##    .BI_crueltyfree    0.946    0.021   45.583    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##     Att_organic       0.505    0.082    6.146    0.000
##     Att_packaging     0.583    0.096    6.097    0.000
##     Att_crueltyfre    0.699    0.101    6.889    0.000
##    .BI_organic        1.000
##    .BI_packaging      1.000
##    .BI_crueltyfree    1.000
##    .Attitude_rgnc1    0.194    0.035    5.481    0.000
##    .Attitude_rgnc2    0.337    0.046    7.357    0.000
##    .Attitude_rgnc3    0.520    0.071    7.283    0.000
##    .Attitd_pckgng1    0.250    0.040    6.327    0.000
##    .Attitd_pckgng2    0.263    0.037    7.072    0.000
##    .Attitd_pckgng3    0.392    0.059    6.606    0.000
##    .Atttd_crltyfr1    0.171    0.031    5.475    0.000
##    .Atttd_crltyfr2    0.364    0.050    7.282    0.000
##    .Atttd_crltyfr3    0.289    0.047    6.079    0.000
##    .BI_organic1       0.245    0.039    6.334    0.000
##    .BI_organic2       0.199    0.033    6.075    0.000
##    .BI_organic3       0.315    0.044    7.246    0.000
##    .BI_packaging1     0.235    0.036    6.589    0.000
##    .BI_packaging2     0.202    0.031    6.432    0.000
##    .BI_packaging3     0.264    0.036    7.234    0.000
##    .BI_crueltyfre1    0.192    0.030    6.289    0.000
##    .BI_crueltyfre2    0.200    0.031    6.536    0.000
##    .BI_crueltyfre3    0.150    0.025    5.921    0.000
```

```
standardizedSolution(fitsem1)
```

```
##                     lhs op                   rhs est.std    se       z pvalue
## 1            Att_organic =~     Attitude_organic1   0.850 0.032  26.362      0
## 2            Att_organic =~     Attitude_organic2   0.721 0.046  15.697      0
## 3            Att_organic =~     Attitude_organic3   0.730 0.045  16.253      0
## 4          Att_packaging =~   Attitude_packaging1   0.837 0.031  26.799      0
## 5          Att_packaging =~   Attitude_packaging2   0.784 0.037  21.057      0
## 6          Att_packaging =~   Attitude_packaging3   0.820 0.033  24.791      0
## 7        Att_crueltyfree =~ Attitude_crueltyfree1   0.896 0.022  40.084      0
## 8        Att_crueltyfree =~ Attitude_crueltyfree2   0.802 0.034  23.920      0
## 9        Att_crueltyfree =~ Attitude_crueltyfree3   0.875 0.025  35.497      0
## 10            BI_organic =~           BI_organic1   0.923 0.012  77.983      0
## 11            BI_organic =~           BI_organic2   0.928 0.013  71.372      0
## 12            BI_organic =~           BI_organic3   0.882 0.018  47.794      0
## 13          BI_packaging =~         BI_packaging1   0.924 0.011  83.039      0
```

```
## 14          BI_packaging =~         BI_packaging2   0.927 0.012  74.482      0
## 15          BI_packaging =~         BI_packaging3   0.895 0.016  54.938      0
## 16        BI_crueltyfree =~       BI_crueltyfree1   0.941 0.009 100.141      0
## 17        BI_crueltyfree =~       BI_crueltyfree2   0.934 0.011  83.427      0
## 18        BI_crueltyfree =~       BI_crueltyfree3   0.948 0.010  97.606      0
## 19           BI_organic  ~           Att_organic   0.539 0.044  12.345      0
## 20         BI_packaging  ~         Att_packaging   0.524 0.043  12.154      0
## 21        BI_crueltyfree  ~       Att_crueltyfree   0.571 0.040  14.316      0
## 22           Att_organic ~~           Att_organic   1.000 0.000      NA     NA
## 23         Att_packaging ~~         Att_packaging   1.000 0.000      NA     NA
## 24       Att_crueltyfree ~~       Att_crueltyfree   1.000 0.000      NA     NA
## 25            BI_organic ~~            BI_organic   0.709 0.047  15.054      0
## 26          BI_packaging ~~          BI_packaging   0.726 0.045  16.092      0
## 27        BI_crueltyfree ~~        BI_crueltyfree   0.674 0.046  14.767      0
## 28     Attitude_organic1 ~~     Attitude_organic1   0.277 0.055   5.049      0
## 29     Attitude_organic2 ~~     Attitude_organic2   0.480 0.066   7.255      0
## 30     Attitude_organic3 ~~     Attitude_organic3   0.467 0.066   7.118      0
## 31   Attitude_packaging1 ~~   Attitude_packaging1   0.300 0.052   5.744      0
## 32   Attitude_packaging2 ~~   Attitude_packaging2   0.385 0.058   6.584      0
## 33   Attitude_packaging3 ~~   Attitude_packaging3   0.327 0.054   6.028      0
## 34 Attitude_crueltyfree1 ~~ Attitude_crueltyfree1   0.197 0.040   4.912      0
## 35 Attitude_crueltyfree2 ~~ Attitude_crueltyfree2   0.357 0.054   6.641      0
## 36 Attitude_crueltyfree3 ~~ Attitude_crueltyfree3   0.234 0.043   5.410      0
## 37           BI_organic1 ~~           BI_organic1   0.148 0.022   6.768      0
## 38           BI_organic2 ~~           BI_organic2   0.138 0.024   5.719      0
## 39           BI_organic3 ~~           BI_organic3   0.223 0.033   6.843      0
## 40         BI_packaging1 ~~         BI_packaging1   0.146 0.021   7.082      0
## 41         BI_packaging2 ~~         BI_packaging2   0.140 0.023   6.062      0
## 42         BI_packaging3 ~~         BI_packaging3   0.199 0.029   6.831      0
## 43       BI_crueltyfree1 ~~       BI_crueltyfree1   0.114 0.018   6.462      0
## 44       BI_crueltyfree2 ~~       BI_crueltyfree2   0.127 0.021   6.069      0
## 45       BI_crueltyfree3 ~~       BI_crueltyfree3   0.102 0.018   5.534      0
## 46           Att_organic ~~         Att_packaging   0.766 0.046  16.701      0
## 47           Att_organic ~~       Att_crueltyfree   0.644 0.059  10.944      0
## 48         Att_packaging ~~       Att_crueltyfree   0.716 0.049  14.541      0
## 49            BI_organic ~~          BI_packaging   0.967 0.021  46.595      0
## 50            BI_organic ~~        BI_crueltyfree   0.910 0.026  34.785      0
## 51          BI_packaging ~~        BI_crueltyfree   0.946 0.021  45.583      0
##    ci.lower ci.upper
## 1     0.787    0.914
## 2     0.631    0.811
## 3     0.642    0.818
## 4     0.775    0.898
## 5     0.711    0.857
## 6     0.755    0.885
## 7     0.852    0.940
## 8     0.736    0.868
## 9     0.827    0.924
## 10    0.900    0.946
## 11    0.903    0.954
## 12    0.846    0.918
## 13    0.902    0.946
## 14    0.903    0.952
## 15    0.863    0.927
```

```
## 16    0.923    0.960
## 17    0.912    0.956
## 18    0.929    0.967
## 19    0.454    0.625
## 20    0.439    0.608
## 21    0.493    0.650
## 22    1.000    1.000
## 23    1.000    1.000
## 24    1.000    1.000
## 25    0.617    0.802
## 26    0.637    0.814
## 27    0.584    0.763
## 28    0.169    0.384
## 29    0.351    0.610
## 30    0.338    0.595
## 31    0.198    0.402
## 32    0.270    0.499
## 33    0.221    0.434
## 34    0.118    0.275
## 35    0.252    0.462
## 36    0.149    0.318
## 37    0.105    0.191
## 38    0.091    0.185
## 39    0.159    0.286
## 40    0.105    0.186
## 41    0.095    0.185
## 42    0.142    0.256
## 43    0.080    0.149
## 44    0.086    0.168
## 45    0.066    0.138
## 46    0.676    0.856
## 47    0.528    0.759
## 48    0.620    0.813
## 49    0.927    1.008
## 50    0.859    0.961
## 51    0.905    0.987
```

```
fitmeasures(fitsem1,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##   chisq      df  pvalue     cfi     tli   rmsea    srmr
## 389.013 129.000   0.000   0.897   0.877   0.116   0.195
```

```
##second step
sem2 <-'# measurement model
        Att_organic=~Attitude_organic1+Attitude_organic2+Attitude_organic3
        Att_packaging=~Attitude_packaging1+Attitude_packaging2+Attitude_packaging3
        Att_crueltyfree=~Attitude_crueltyfree1+Attitude_crueltyfree2+Attitude_crueltyfree3
        BI_organic=~1*BI_organic1+BI_organic2+BI_organic3
        BI_packaging=~1*BI_packaging1+BI_packaging2+BI_packaging3
        BI_crueltyfree=~1*BI_crueltyfree1+BI_crueltyfree2+BI_crueltyfree3

        # structural model(regressions)
        BI_organic~a*Att_organic
```

```
        BI_packaging~a*Att_packaging
        BI_crueltyfree~a*Att_crueltyfree

        #variance latent variables
        Att_organic~~Att_organic
        Att_packaging~~Att_packaging
        Att_crueltyfree~~Att_crueltyfree
        BI_organic~~1*BI_organic
        BI_packaging~~1*BI_packaging
        BI_crueltyfree~~1*BI_crueltyfree'


fitsem2 <- sem(sem2, data =ccosmetics)
summary(fitsem2, fit.measure = TRUE)
```

```
## lavaan 0.6-12 ended normally after 48 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        42
##   Number of equality constraints                     2
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               389.924
##   Degrees of freedom                               131
##   P-value (Chi-square)                           0.000
##
## Model Test Baseline Model:
##
##   Test statistic                              2667.493
##   Degrees of freedom                               153
##   P-value                                        0.000
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.897
##   Tucker-Lewis Index (TLI)                       0.880
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -2697.061
##   Loglikelihood unrestricted model (H1)      -2502.099
##
##   Akaike (AIC)                                5474.121
##   Bayesian (BIC)                              5594.546
##   Sample-size adjusted Bayesian (BIC)         5467.954
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.115
```

```
##   90 Percent confidence interval - lower         0.102
##   90 Percent confidence interval - upper         0.128
##   P-value RMSEA <= 0.05                          0.000
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.194
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                     Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic =~
##     Attitude_rgnc1      1.000
##     Attitude_rgnc2      0.827    0.081   10.191    0.000
##     Attitude_rgnc3      1.054    0.102   10.380    0.000
##   Att_packaging =~
##     Attitd_pckgng1      1.000
##     Attitd_pckgng2      0.870    0.074   11.811    0.000
##     Attitd_pckgng3      1.208    0.095   12.778    0.000
##   Att_crueltyfree =~
##     Atttd_crltyfr1      1.000
##     Atttd_crltyfr2      0.972    0.074   13.169    0.000
##     Atttd_crltyfr3      1.167    0.074   15.685    0.000
##   BI_organic =~
##     BI_organic1         1.000
##     BI_organic2         0.953    0.041   23.516    0.000
##     BI_organic3         0.896    0.046   19.347    0.000
##   BI_packaging =~
##     BI_packaging1       1.000
##     BI_packaging2       0.940    0.039   23.922    0.000
##     BI_packaging3       0.869    0.042   20.653    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1      1.000
##     BI_crueltyfre2      0.961    0.038   25.107    0.000
##     BI_crueltyfre3      0.942    0.035   27.001    0.000
##
## Regressions:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~
##     Att_organc (a)    0.838    0.073   11.411    0.000
##   BI_packaging ~
##     Att_pckgng (a)    0.838    0.073   11.411    0.000
##   BI_crueltyfree ~
##     Att_crltyf (a)    0.838    0.073   11.411    0.000
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   Att_organic ~~
##     Att_packaging     0.416    0.065    6.360    0.000
```

```
##     Att_crueltyfre    0.390    0.067    5.835    0.000
##   Att_packaging ~~
##     Att_crueltyfre    0.444    0.071    6.247    0.000
##  .BI_organic ~~
##    .BI_packaging      0.965    0.020   47.183    0.000
##    .BI_crueltyfree    0.907    0.026   35.111    0.000
##  .BI_packaging ~~
##    .BI_crueltyfree    0.947    0.021   45.384    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##     Att_organic       0.534    0.079    6.797    0.000
##     Att_packaging     0.555    0.082    6.743    0.000
##     Att_crueltyfre    0.695    0.097    7.168    0.000
##    .BI_organic        1.000
##    .BI_packaging      1.000
##    .BI_crueltyfree    1.000
##    .Attitude_rgnc1    0.186    0.035    5.385    0.000
##    .Attitude_rgnc2    0.337    0.046    7.365    0.000
##    .Attitude_rgnc3    0.520    0.071    7.292    0.000
##    .Attitd_pckgng1    0.255    0.039    6.581    0.000
##    .Attitd_pckgng2    0.264    0.037    7.073    0.000
##    .Attitd_pckgng3    0.389    0.059    6.573    0.000
##    .Atttd_crltyfr1    0.172    0.031    5.559    0.000
##    .Atttd_crltyfr2    0.363    0.050    7.276    0.000
##    .Atttd_crltyfr3    0.289    0.048    6.082    0.000
##    .BI_organic1       0.246    0.039    6.378    0.000
##    .BI_organic2       0.198    0.033    6.021    0.000
##    .BI_organic3       0.315    0.044    7.223    0.000
##    .BI_packaging1     0.236    0.036    6.581    0.000
##    .BI_packaging2     0.202    0.031    6.448    0.000
##    .BI_packaging3     0.264    0.036    7.249    0.000
##    .BI_crueltyfre1    0.192    0.031    6.287    0.000
##    .BI_crueltyfre2    0.200    0.031    6.539    0.000
##    .BI_crueltyfre3    0.150    0.025    5.924    0.000
```

```
standardizedSolution(fitsem2)
```

```
##                      lhs op                   rhs label est.std    se       z
## 1            Att_organic =~     Attitude_organic1         0.861 0.029  29.989
## 2            Att_organic =~     Attitude_organic2         0.721 0.046  15.732
## 3            Att_organic =~     Attitude_organic3         0.730 0.045  16.281
## 4          Att_packaging =~   Attitude_packaging1         0.828 0.029  28.267
## 5          Att_packaging =~   Attitude_packaging2         0.784 0.037  20.954
## 6          Att_packaging =~   Attitude_packaging3         0.822 0.033  24.921
## 7        Att_crueltyfree =~ Attitude_crueltyfree1         0.895 0.022  41.389
## 8        Att_crueltyfree =~ Attitude_crueltyfree2         0.802 0.033  23.950
## 9        Att_crueltyfree =~ Attitude_crueltyfree3         0.875 0.025  35.471
## 10            BI_organic =~           BI_organic1         0.921 0.012  78.487
## 11            BI_organic =~           BI_organic2         0.929 0.013  71.561
## 12            BI_organic =~           BI_organic3         0.882 0.018  47.966
## 13         BI_packaging =~         BI_packaging1         0.924 0.011  83.881
## 14         BI_packaging =~         BI_packaging2         0.927 0.013  74.094
## 15         BI_packaging =~         BI_packaging3         0.894 0.016  54.488
```

```
## 16        BI_crueltyfree =~       BI_crueltyfree1         0.941 0.009 100.850
## 17        BI_crueltyfree =~       BI_crueltyfree2         0.934 0.011  83.357
## 18        BI_crueltyfree =~       BI_crueltyfree3         0.948 0.010  97.571
## 19            BI_organic  ~           Att_organic     a   0.522 0.040  13.069
## 20          BI_packaging  ~         Att_packaging     a   0.530 0.040  13.205
## 21        BI_crueltyfree  ~       Att_crueltyfree     a   0.573 0.039  14.781
## 22           Att_organic ~~           Att_organic         1.000 0.000      NA
## 23         Att_packaging ~~         Att_packaging         1.000 0.000      NA
## 24       Att_crueltyfree ~~       Att_crueltyfree         1.000 0.000      NA
## 25            BI_organic ~~            BI_organic         0.727 0.042  17.411
## 26          BI_packaging ~~          BI_packaging         0.719 0.042  16.927
## 27        BI_crueltyfree ~~        BI_crueltyfree         0.672 0.044  15.137
## 28     Attitude_organic1 ~~     Attitude_organic1         0.259 0.049   5.230
## 29     Attitude_organic2 ~~     Attitude_organic2         0.480 0.066   7.261
## 30     Attitude_organic3 ~~     Attitude_organic3         0.467 0.066   7.126
## 31   Attitude_packaging1 ~~   Attitude_packaging1         0.315 0.048   6.495
## 32   Attitude_packaging2 ~~   Attitude_packaging2         0.386 0.059   6.590
## 33   Attitude_packaging3 ~~   Attitude_packaging3         0.325 0.054   5.996
## 34 Attitude_crueltyfree1 ~~ Attitude_crueltyfree1         0.198 0.039   5.119
## 35 Attitude_crueltyfree2 ~~ Attitude_crueltyfree2         0.357 0.054   6.635
## 36 Attitude_crueltyfree3 ~~ Attitude_crueltyfree3         0.234 0.043   5.413
## 37           BI_organic1 ~~           BI_organic1         0.152 0.022   7.011
## 38           BI_organic2 ~~           BI_organic2         0.137 0.024   5.681
## 39           BI_organic3 ~~           BI_organic3         0.222 0.032   6.843
## 40         BI_packaging1 ~~         BI_packaging1         0.145 0.020   7.135
## 41         BI_packaging2 ~~         BI_packaging2         0.141 0.023   6.078
## 42         BI_packaging3 ~~         BI_packaging3         0.201 0.029   6.850
## 43       BI_crueltyfree1 ~~       BI_crueltyfree1         0.114 0.018   6.498
## 44       BI_crueltyfree2 ~~       BI_crueltyfree2         0.127 0.021   6.072
## 45       BI_crueltyfree3 ~~       BI_crueltyfree3         0.102 0.018   5.537
## 46           Att_organic ~~         Att_packaging         0.765 0.046  16.613
## 47           Att_organic ~~       Att_crueltyfree         0.640 0.059  10.845
## 48         Att_packaging ~~       Att_crueltyfree         0.716 0.049  14.500
## 49            BI_organic ~~          BI_packaging         0.965 0.020  47.183
## 50            BI_organic ~~        BI_crueltyfree         0.907 0.026  35.111
## 51          BI_packaging ~~        BI_crueltyfree         0.947 0.021  45.384
##    pvalue ci.lower ci.upper
## 1       0    0.805    0.917
## 2       0    0.631    0.811
## 3       0    0.642    0.818
## 4       0    0.770    0.885
## 5       0    0.710    0.857
## 6       0    0.757    0.886
## 7       0    0.853    0.938
## 8       0    0.737    0.868
## 9       0    0.827    0.924
## 10      0    0.898    0.944
## 11      0    0.904    0.954
## 12      0    0.846    0.918
## 13      0    0.903    0.946
## 14      0    0.902    0.951
## 15      0    0.862    0.926
## 16      0    0.923    0.959
## 17      0    0.912    0.956
```

```
## 18      0    0.929    0.967
## 19      0    0.444    0.601
## 20      0    0.451    0.608
## 21      0    0.497    0.649
## 22     NA    1.000    1.000
## 23     NA    1.000    1.000
## 24     NA    1.000    1.000
## 25      0    0.645    0.809
## 26      0    0.636    0.803
## 27      0    0.585    0.759
## 28      0    0.162    0.356
## 29      0    0.350    0.610
## 30      0    0.338    0.595
## 31      0    0.220    0.410
## 32      0    0.271    0.501
## 33      0    0.219    0.431
## 34      0    0.122    0.274
## 35      0    0.251    0.462
## 36      0    0.149    0.319
## 37      0    0.109    0.194
## 38      0    0.090    0.184
## 39      0    0.158    0.286
## 40      0    0.105    0.185
## 41      0    0.095    0.186
## 42      0    0.143    0.258
## 43      0    0.080    0.149
## 44      0    0.086    0.168
## 45      0    0.066    0.138
## 46      0    0.674    0.855
## 47      0    0.524    0.756
## 48      0    0.619    0.813
## 49      0    0.925    1.005
## 50      0    0.857    0.958
## 51      0    0.906    0.988
```

```
fitmeasures(fitsem2,c("chisq","df","pvalue","cfi","tli","rmsea","srmr"))
```

```
##   chisq      df  pvalue     cfi     tli   rmsea    srmr
## 389.924 131.000   0.000   0.897   0.880   0.115   0.194
```

The results indicates that the step2 model is still rejected by a good ness of fit test(chi-square=389.9, df=131, p<.001). And for the descriptive fit, the model does not fit the covariance matrix well(CFI=.897, TLI=.880, RMSEA=.115, SRMR=.194).

From the result, we can see that there is a significant positive effect of importance of attitude on behavior intention. With a standard deviation increase in each of the attention score, the score on behavior intention factor will each increase by 11.41 standard deviation.

```
#model fit comparison
anova(fitsem1, fitsem2)
```

```
## Chi-Squared Difference Test
##
```

```
##          Df    AIC    BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fitsem1 129 5477.2 5603.7 389.01
## fitsem2 131 5474.1 5594.5 389.92    0.91035       2     0.6343
```

Since we accept the null hypothesis using the chi-squared difference of fit test, this means that we do not need to impose the constraint that the 3 population regression coefficients of the structural model are equal.But according to the value of AIC and BIC, the second model is better than the first one.

From the standardized solution, we can find that all variables of behavior intention have significant and positive standardized loadings that exceed 0.7. But for attitude, only the reliabilities of att_organic1, att_crueltyfree1 and att_crueltyfree3 are exceed 0.7.

The factor score of Att_organic and Att_packaging have a composite reliability of .59 and .67, so they don't have acceptance reliability. But for Att_crueltyfree, BI_organic, BI_packaging and BI_crueltyfree, the composite reliabilities are 0.74, 0.83, 0.84 and 0.89, so they all have acceptance reliability.

Attitude items all have significant positive effect on behavior intention items(Att_organic on BI_organic, Att_packaging on BI_packaging and Att_Crueltyfree on BI_crueltyfree. The estimated correlations between each of them are 0.522, 0.530 and 0.573.

Task 2

PART A

We load the data, standardize the variables, use the candisc() procedure to conduct canonical correlation analysis and print a summary of the results and compute redundancies.

```
load("/Users/yavuzhanyavuz/Desktop/Leuven/Multivariate/benefits.Rdata")

library(candisc)
#conduct canonical correlation analysis

z_benefits = benefits ##first update, we need to normalize the datq
z_benefits[,2:14]<-scale(benefits[,2:14],center=TRUE,scale=TRUE)

cancor.out<-cancor(cbind(SL_pensioners,SL_unemployed,SL_old_gvntresp,SL_unemp_gvntresp)
                   ~SB_strain_economy+SB_prevent_poverty+SB_equal_society
                   +SB_taxes_business+SB_make_lazy+SB_caring_others
                   +unemployed_notmotivated+SB_often_lessthanentitled
                   +SB_often_notentitled,data=z_benefits)
```

```
summary(cancor.out)
```

```
##
## Canonical correlation analysis of:
##   9   X  variables:  SB_strain_economy, SB_prevent_poverty, SB_equal_society, SB_taxes_business, SB_
##   with    4   Y  variables:  SL_pensioners, SL_unemployed, SL_old_gvntresp, SL_unemp_gvntresp
##
##      CanR   CanRSQ   Eigen percent    cum                           scree
## 1 0.48323 0.233515 0.30466 79.8465  79.85 ******************************
## 2 0.22817 0.052061 0.05492 14.3939  94.24 *****
```

```
## 3 0.13741 0.018883 0.01925  5.0442  99.28 **
## 4 0.05218 0.002723 0.00273  0.7155 100.00
##
## Test of H0: The canonical correlations in the
## current row and all that follow are zero
##
##      CanR LR test stat approx F numDF   denDF   Pr(> F)
## 1 0.48323      0.71092   32.719    36 12357.1 < 2.2e-16 ***
## 2 0.22817      0.92751   10.477    24  9565.8 < 2.2e-16 ***
## 3 0.13741      0.97845    5.163    14  6598.0 8.545e-10 ***
## 4 0.05218      0.99728    1.501     6  3300.0    0.1735
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Raw canonical coefficients
##
##    X  variables:
##                               Xcan1      Xcan2     Xcan3     Xcan4
## SB_strain_economy         -0.0909717  0.4172121  0.564470 -0.059128
## SB_prevent_poverty         0.0779679 -0.0254661 -0.329579 -0.125299
## SB_equal_society           0.1279718  0.3828047 -0.585296 -0.097459
## SB_taxes_business         -0.0850983  0.0972611 -0.067364 -0.947887
## SB_make_lazy              -0.3819813  0.0411048 -0.206351  0.231770
## SB_caring_others           0.0069064  0.0060264  0.128499 -0.149934
## unemployed_notmotivated   -0.4933957 -0.1393655 -0.333507  0.134556
## SB_often_lessthanentitled  0.2525276 -0.6831611  0.127790 -0.360191
## SB_often_notentitled      -0.1393188 -0.4867982 -0.255268  0.146316
##
##    Y  variables:
##                        Ycan1     Ycan2    Ycan3    Ycan4
## SL_pensioners       0.220475  0.651836 -0.28265  0.78198
## SL_unemployed      -0.526682  0.156985 -0.64871 -0.63976
## SL_old_gvntresp    -0.098433 -0.599184 -0.55693  0.72377
## SL_unemp_gvntresp   0.764899  0.057483 -0.33698 -0.71784
```

```
#computing redundancies from output
R2tu<-cancor.out$cancor^2
VAFYbyt<-apply(cancor.out$structure$Y.yscores^2,2,sum)/4 ##updated 5 to 4, now they match with redundan
redund<-R2tu*VAFYbyt
round(cbind(R2tu,VAFYbyt,redund,total=cumsum(redund)),4)
```

```
##         R2tu VAFYbyt redund  total
## Ycan1 0.2335  0.2850 0.0665 0.0665
## Ycan2 0.0521  0.3200 0.0167 0.0832
## Ycan3 0.0189  0.2727 0.0051 0.0883
## Ycan4 0.0027  0.1224 0.0003 0.0887
```

The canonical correlation analysis extracts four pairs of canonical variates. Hypotheses tests indicate that the fourth pair can be ignored as the canonical correlation is not significant, i.e., H_0: $\rho(u_4,t_4) = 0$ cannot be rejected at the 5% level (p=.1735).

The first canonical correlation equals 0.483. This means that the canonical variate u_1 accounts for 23.35% of the variance in the canonical variate t_1 . The second canonical correlation equals 0.228. This means that the canonical variate u_2 accounts for 5.21% of the variance in the canonical variate t_2.

As shown by the redundancies, the first three pairs of canonical variates account for 8.88% of the variance in the Y variables. The first pair of canonical variates is most relevant at accounting for the variance in the Y variables by a score of 6.65%. The second pair of canonical variates contributes by 1.67% and the third accounts for only 0.5% in the explanation of the variance of Y. We decided to keep third canonical variate because it increases the total explanation of variance Y by 6% (0.0051/0.0832). In conclusion, three pairs are included in the interpretation of the relation but contributions decrease respectively with the pairs.

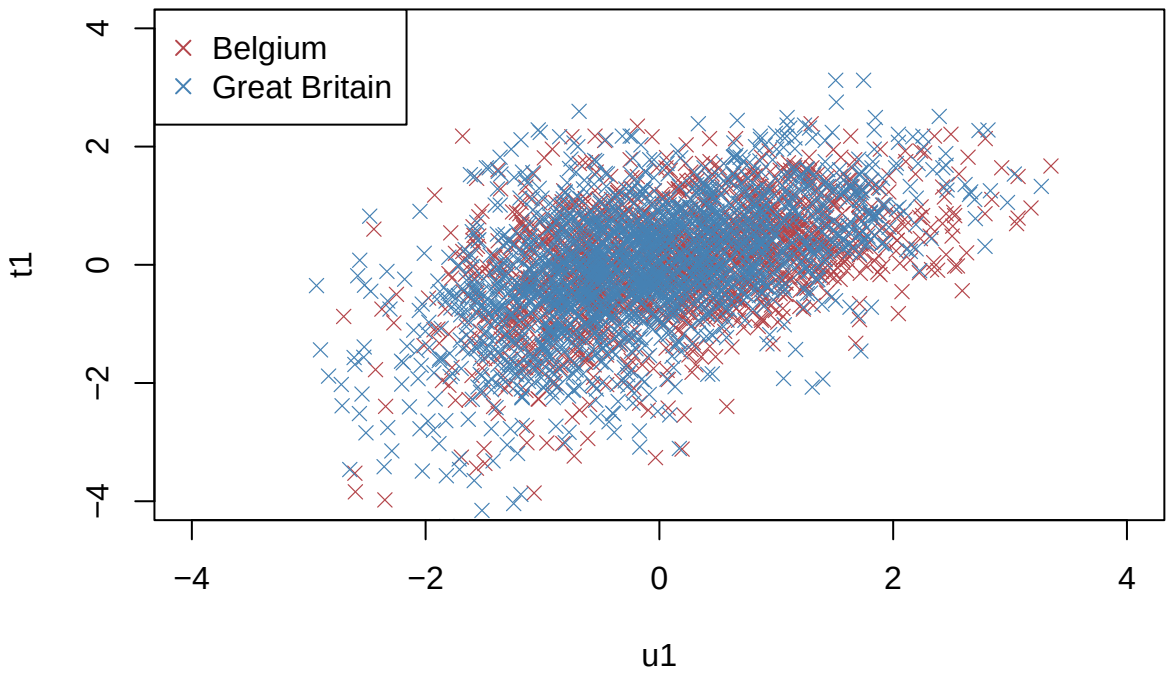
Therefore, we will analyze the first pair of canonical variates. To interpret the first pair of canonical variates, we print the canonical loadings (=correlation between the canonical variates and the X and Y variables). In addition, we make a scatter plot of the first pair of canonical variates and indicate a different color for observations of each country.

```
#print canonical loadings
round(cancor.out$structure$X.xscores,2)
```

```
##                           Xcan1 Xcan2 Xcan3 Xcan4
## SB_strain_economy         -0.54  0.27  0.44 -0.27
## SB_prevent_poverty         0.22  0.10 -0.53 -0.18
## SB_equal_society           0.33  0.33 -0.73 -0.15
## SB_taxes_business         -0.45  0.12  0.01 -0.85
## SB_make_lazy              -0.80 -0.02 -0.02 -0.05
## SB_caring_others          -0.56 -0.06  0.07 -0.21
## unemployed_notmotivated   -0.80 -0.19 -0.26 -0.02
## SB_often_lessthanentitled  0.30 -0.73  0.06 -0.36
## SB_often_notentitled      -0.56 -0.47 -0.19  0.00
```

```
round(cancor.out$structure$Y.yscores,2)
```

```
##                   Ycan1 Ycan2 Ycan3 Ycan4
## SL_pensioners      0.18  0.81 -0.36  0.42
## SL_unemployed     -0.61  0.31 -0.65 -0.32
## SL_old_gvntresp    0.11 -0.71 -0.60  0.34
## SL_unemp_gvntresp  0.85 -0.11 -0.42 -0.30
```



The canonical loadings indicate that Y variables are split on first two canonical variates based on question's topic, unemployed vs pensioners. t_1 has relatively higher correlation on two Y variables which are regarding unemployment of the people while t_2 has relatively higher correlation with questions regarding pensioners. Regarding the interpretation, high score on t_1 means that the respondent thinks standard living of unemployed people is poor and it is government's responsibility. On the other hand, t_2 is the inverse of t_1. **Low score** on t_2 means that the respondent believes standard living of pensioners is poor and it is government's responsibility.

Similarly, u_1 is more correlated on questions about laziness and motivation of unemployed people. High score on u_1 means that respondent strongly disagrees with the idea that social benefits/services make people lazy and unemployment is their fault while also disagreeing that those people are unwilling to care for others when they receive benefits/services and obtain social benefits/services that are not entitled to them.

There is no clear distinction on first canonical variates between countries. Both countries have respondents for every point of view. But we can conclude that slight positive correlation between canonical variates align with respondent's perspective on both X and Y variables that have relatively higher correlation.

PART B

```
#split data in two parts and standardize data
train<-z_benefits[seq(2,nrow(z_benefits),by=2),]
valid<-z_benefits[seq(1,nrow(z_benefits),by=2),]
train[,2:14]<-scale(train[,2:14],center=TRUE,scale=TRUE)
valid[,2:14]<-scale(valid[,2:14],center=TRUE,scale=TRUE)

#conduct CCA on calibration data
```

```
cancor.train<-cancor(cbind(SL_pensioners,SL_unemployed,SL_old_gvntresp,SL_unemp_gvntresp)
                     ~SB_strain_economy+SB_prevent_poverty+SB_equal_society
                     +SB_taxes_business+SB_make_lazy+SB_caring_others
                     +unemployed_notmotivated+SB_often_lessthanentitled
                     +SB_often_notentitled,data=train)

#conduct CCA on validation data
cancor.valid<-cancor(cbind(SL_pensioners,SL_unemployed,SL_old_gvntresp,SL_unemp_gvntresp)
                     ~SB_strain_economy+SB_prevent_poverty+SB_equal_society
                     +SB_taxes_business+SB_make_lazy+SB_caring_others
                     +unemployed_notmotivated+SB_often_lessthanentitled
                     +SB_often_notentitled,data=valid)

# canonical variates calibration set
train.X1<-cancor.train$score$X
train.Y1<-cancor.train$score$Y

# compute canonical variates using data of calibration set and
#coefficients estimated on validation set
train.Y2<-as.matrix(train[,2:5])%*%cancor.valid$coef$Y
train.X2<-as.matrix(train[,6:14])%*%cancor.valid$coef$X
```

```
#R(U*,T*) versus R(U,T)
round(cor(train.X2,train.Y2)[1:4,1:4],3)
```

```
##       Ycan1  Ycan2 Ycan3  Ycan4
## Xcan1 0.468 -0.067 0.065 -0.026
## Xcan2 0.019  0.215 0.022  0.011
## Xcan3 0.019  0.043 0.089  0.016
## Xcan4 0.040 -0.076 0.027  0.011
```

```
round(cor(train.X1,train.Y1)[1:4,1:4],3)
```

```
##       Ycan1 Ycan2 Ycan3 Ycan4
## Xcan1 0.482 0.000 0.000 0.000
## Xcan2 0.000 0.244 0.000 0.000
## Xcan3 0.000 0.000 0.145 0.000
## Xcan4 0.000 0.000 0.000 0.046
```

When diagonal elements are compared, it is seen thqt R(U$*$,T$*$) has slightly lower correlation values than R(U,T) for first two canonical variate pairs while the third one has a rather larger overestimation. The fourth pair may be skipped as it is also neglected in the model. Off-diagonal elements of R(U$*$,T$*$) are rather small and smaller in absolute values than diagonal elements. To sum up, overestimation due to maximization involved is not an issue.

```
#R(T*,T*) and R(U*,U*)
round(cor(train.Y2,train.Y2)[1:4,1:4],3)
```

```
##        Ycan1  Ycan2 Ycan3 Ycan4
## Ycan1  1.000 -0.050 0.001 0.006
## Ycan2 -0.050  1.000 0.014 0.034
## Ycan3  0.001  0.014 1.000 0.010
## Ycan4  0.006  0.034 0.010 1.000
```

```
round(cor(train.X2,train.X2)[1:4,1:4],3)
```

```
##        Xcan1  Xcan2  Xcan3 Xcan4
## Xcan1  1.000 -0.037 -0.047 0.020
## Xcan2 -0.037  1.000  0.024 0.017
## Xcan3 -0.047  0.024  1.000 0.035
## Xcan4  0.020  0.017  0.035 1.000
```

The off-diagonal elements of R(T∗,T∗) and R(U∗,U∗) are close to 0, which indicates that canonical variates of Y variables and of X variables computed on calibration data but based on the coefficients from validation data have as expected correlations that are close to 0. It can be concluded that they are independent.

Part C

```
#R(T,T*) and R(U,U*)
round(cor(train.Y1,train.Y2)[1:4,1:4],3)
```

```
##        Ycan1  Ycan2  Ycan3  Ycan4
## Ycan1 -0.985  0.121 -0.148  0.044
## Ycan2 -0.057 -0.989 -0.116 -0.036
## Ycan3  0.146  0.083 -0.973 -0.145
## Ycan4  0.069  0.006 -0.130  0.988
```

```
round(cor(train.X1,train.X2)[1:4,1:4],3)
```

```
##        Xcan1  Xcan2  Xcan3  Xcan4
## Xcan1 -0.985 -0.013 -0.058 -0.100
## Xcan2  0.040 -0.893 -0.219  0.283
## Xcan3  0.031  0.027 -0.557 -0.206
## Xcan4 -0.091  0.100  0.072  0.257
```

The absolute value of the diagonal elements of R(T,T∗) and R(U,U∗) represent the reliabilities of the canonical variates for Y and X variables. The reliabilities of t_1, t_2, t_3, t_4 are .985, .989, .973 and .988, respectively. Also, the reliabilities of u_1, u_2, u_3, u_4 are as follows: .985, .893, .557 and .257. Subsequently, it can be concluded that first two pairs of canonical variates have acceptable reliability while remaining pairs have unacceptable reliability. Considering the redundancy analysis and canonical correlation hypothesis model, it is seen first two pairs are both important and reliable.

‘‘‘