Assignment 2

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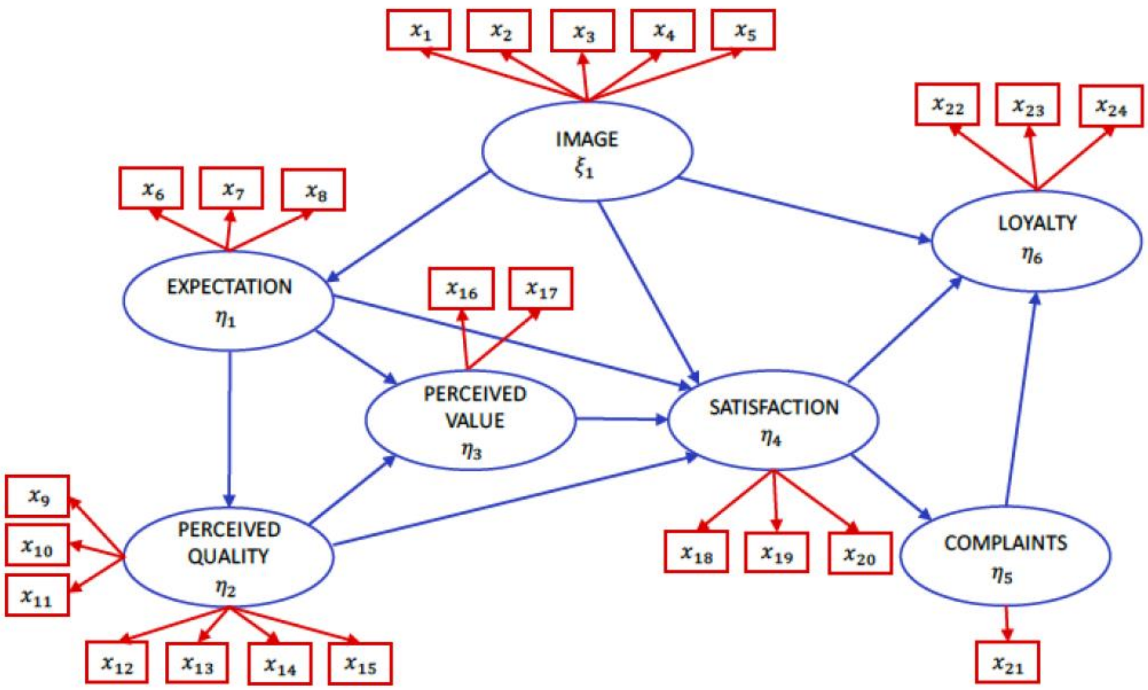
Course: Advances in data analysis and statistical modelling

Path analysis and Structural Equation Modelling.

1) Define a sequential structural equation models on ECSI dataset included in the folder. In particular, apply 7 different principal component model (one for each block) and take only the first principal component obtained by each block. Subsequently, through the application of regression models, use these obtained component scores to construct a path model as shown in the figure below.



The dataset including 250 observations that has 24 variables (showed as x_i)

Endogenous:

η_1: $Expectation\ (x_6, x_7, x_8) \rightarrow (exp1, exp2, exp3)$

η_2: $Perceived\ Quality\ (x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}) \rightarrow (qua1, qua2, qua3, qua4, qua5, qua6, qua7)$

η_3: $Perceived\ Value\ (x_{16}, x_{17}) \rightarrow (val1, val2)$

η_4: $Satisfaction\ (x_{18}, x_{19}, x_{20}) \rightarrow (sat1, sat2, sat3)$

$\eta_5: Complaints\ (x_{21}) \rightarrow (com)$

$\eta_6: Loyality\ (x_{22}, x_{23}, x_{24}) \rightarrow (loy1, loy2, loy3)$

Exogenous:

$\xi_1: Image(x_1, x_2, x_3, x_4, x_5) \rightarrow (ima1, ima2, ima3, ima4, ima5)$

Using "FactoMineR" package, R is able to setup PCA, the first lines of the following code import the dataset to R and also activate the packages that are needed for both PCA + Regression and SEM model. Only the summary results of the first Regression model on LV is shown on the report to avoid repetitive results.

```
# Read Dataset and R initiating -------------------------------------------
data <- read.table("data.txt", header = TRUE)
names(data)
##  [1] "ima1" "ima2" "ima3" "ima4" "ima5" "exp1" "exp2" "exp3" "qua1" "qua2"
## [11] "qua3" "qua4" "qua5" "qua6" "qua7" "val1" "val2" "sat1" "sat2" "sat3"
## [21] "comp" "loy1" "loy2" "loy3"
attach(data)
library(lavaan)
library(semPlot)
library(FactoMineR)

# PCA ---------------------------------------------------------------------
# ima  ~ ima1 + ima2 + ima3 + ima4 + ima5
ima = PCA(X = data[,c(1:5)], ncp = 1)
ima = ima$ind$coord

# exp  ~ exp1 + exp2 + exp3
exp = PCA(X = data[,c(6:8)], ncp = 1)
exp = exp$ind$coord

# qua  ~ qua1 + qua2 + qua3 + qua4 + qua5 + qua6 + qua7
qua = PCA(X = data[,c(9:15)], ncp = 1)
qua = qua$ind$coord

# val  ~ val1 + val2
val = PCA(X = data[,c(16:17)], ncp = 1)
```

```
val = val$ind$coord

# sat  ~ sat1 + sat2 + sat3
sat = PCA(X = data[,c(18:20)], ncp = 1)
sat = sat$ind$coord

# Comp ~ comp
Comp = scale(data[,21])

# loy  ~ loy1 + loy2 + loy3
loy = PCA(X = data[,c(22:24)], ncp = 1)
loy = loy$ind$coord



# Regression Model --------------------------------------------------------

loy.r = lm(formula = loy  ~ ima + sat + comp)
summary(loy.r)
##
## Call:
## lm(formula = loy ~ ima + sat + comp)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.2211 -0.3811  0.1041  0.5247  3.1745
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.209259   0.200812  -1.042  0.29840
## ima          0.169904   0.054449   3.120  0.00202 **
## sat          0.395214   0.060163   6.569 2.99e-10 ***
## comp         0.003104   0.002842   1.092  0.27584
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 0.9504 on 246 degrees of freedom
## Multiple R-squared:  0.4307, Adjusted R-squared:  0.4237
## F-statistic: 62.03 on 3 and 246 DF,  p-value: < 2.2e-16
```

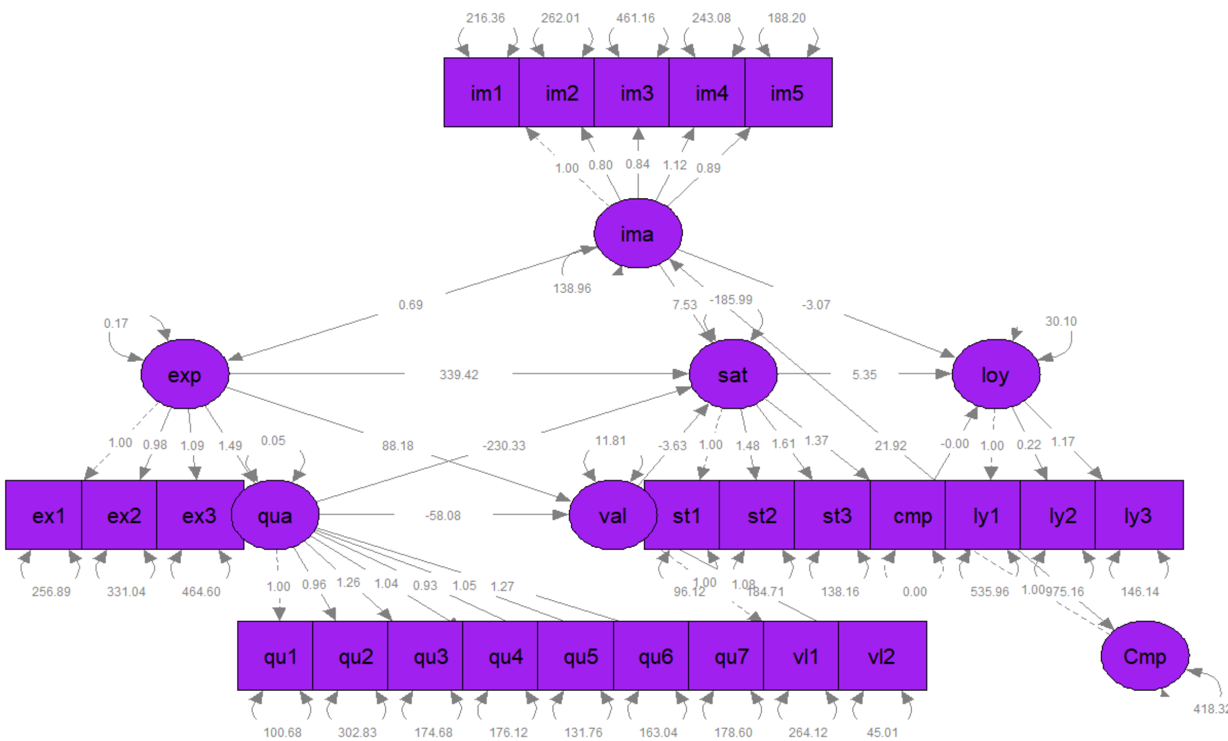
```
comp.r = lm(formula = comp ~ sat)
summary(comp.r)
sat.r = lm(formula = sat  ~ ima + exp + val + qua)
summary(sat.r)
val.r = lm(formula = val  ~ exp + qua)
summary(val.r)
qua.r = lm(formula = qua  ~ exp)
summary(qua.r)
exp.r = lm(formula = exp  ~ ima)
summary(exp.r)
```

2) Through “lavaan” R package, apply the structural equation modelling (SEM) on the same dataset and using the same theoretical path model. Use the “semPath” R package to represent your path model.

With the help of the handy packages such lavaan and semPlot, the SEM model can be made and visualized in R. The initial steps are common with the first question and ignored. Based on the figure the arrows show the measurement and structural model. That can be translated to lavaan package as follow:

```
# Specify and estimate model ---------------------------------------------
model <- '
          # measurement model
          ima  =~ ima1 + ima2 + ima3 + ima4 + ima5
          exp  =~ exp1 + exp2 + exp3
          qua  =~ qua1 + qua2 + qua3 + qua4 + qua5 + qua6 + qua7
          val  =~ val1 + val2
          Comp =~ comp
          sat  =~ sat1 + sat2 + sat3
          loy  =~ loy1 + loy2 + loy3
          # structural model
          loy  ~ ima + sat + comp
```

```
comp ~ sat
sat  ~ ima + exp + val + qua
val  ~ exp + qua
qua  ~ exp
exp  ~ ima
'
```



Model Assessment

gfi	rmsea	aic	bic
0.832	0.075	50912.956	51124.244

Where:

gfi is Goodness of Fit
rmsea is the Root Mean Square Error of Approximation
aic is Akaike's An Information Criterion
bic is Bayesian Information Criterion

3) Create a ranking with respect to "satisfaction" latent scores obtained in point 1) and point 2). Who is the most satisfied?

To leave comment on satisfaction, we first take a look at loadings of satisfaction that are all posit ive. So, we are sure there is no compensation among manifest variables (sat1, sat2, sat3). So the highest value that satisfaction takes, means the highest arithmetic means of sat1, sat2 and sat3 wi th respect to positive weights.

The simple command in R shows the person with highest satisfaction.

```
which.max(satisfaction)

[1] 4
```

Thus, the 4’th one is the most satisfied person.