Module_I

10/30/2023

Example:

- Read in the data file (hdl.csv). (n = 26)

```
data = read.csv(file="hdl.csv",header=T)
attach(data)
head(data)
```

```
##   idnum group weight  hdl
## 1     1     1  163.5 75.0
## 2     2     1  180.0 72.5
## 3     3     1  178.5 62.0
## 4     4     1  161.5 60.0
## 5     5     1  127.0 53.0
## 6     6     1  161.0 53.0
```

The MLR model

```
G1 = as.numeric(group==1)
G2 = as.numeric(group==2)
G3 = as.numeric(group==3)
wt = weight - mean(weight)
m1 = lm(hdl~-1+I(G1)+I(G2)+I(G3)+I(G1*wt)+I(G2*wt)+I(G3*wt))
# alternatively: lm(hdl~-1+factor(group)*wt-wt)
summary(m1)$coef
```

```
##                Estimate Std. Error    t value     Pr(>|t|)
## I(G1)       61.7029920  3.4335268 17.9707325 8.238699e-14
## I(G2)       53.1162611  3.4336920 15.4691399 1.361957e-12
## I(G3)       64.1608327  2.9506956 21.7443077 2.175830e-15
## I(G1 * wt)   0.2495631  0.2005974  1.2440992 2.278470e-01
## I(G2 * wt)   0.2509357  0.1050648  2.3883896 2.689778e-02
## I(G3 * wt) -0.0821306  0.1005492 -0.8168202 4.236546e-01
```

GLH test for parallelism

```
(Contrast.T = matrix(c(0,0,0,1,-1,0,0,0,0,0,1,-1),byrow=T,nrow=2))
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    0    0    0    1   -1    0
## [2,]    0    0    0    0    1   -1
```

```
car::linearHypothesis(model=m1,hypothesis.matrix=Contrast.T,rhs=c(0,0))
```

```
## Warning in printHypothesis(L, rhs, names(b)): one or more coefficients in th
##      arithmetic operators in their names;
##   the printed representation of the hypothesis will be omitted

## Linear hypothesis test
##
## Hypothesis:
##
##
##
## Model 1: restricted model
## Model 2: hdl ~ -1 + I(G1) + I(G2) + I(G3) + I(G1 * wt) + I(G2 * wt) +
##     I(G3 * wt)
##
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     22 2217.4
## 2     20 1712.4  2    505.05 2.9495 0.07542 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

GLH test for equality of intercepts

```
(Contrast.T = matrix(c(1,-1,0,0,0,0,0,1,-1,0,0,0),byrow=T,nrow=2))
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    1   -1    0    0    0    0
## [2,]    0    1   -1    0    0    0
```

```
car::linearHypothesis(model=m1,hypothesis.matrix=Contrast.T,rhs=c(0,0))
```

```
## Linear hypothesis test
##
## Hypothesis:
## I(G1) - I(G2) = 0
## I(G2) - I(G3) = 0
##
## Model 1: restricted model
## Model 2: hdl ~ -1 + I(G1) + I(G2) + I(G3) + I(G1 * wt) + I(G2 * wt) +
##     I(G3 * wt)
##
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     22 2247.3
## 2     20 1712.4  2    534.97 3.1242 0.06596 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The MLR model reparameterized

```
m2 = lm(hdl~I(G2)+I(G3)+I(wt)+I(G2*wt)+I(G3*wt))
anova(m2) #Sequential SS (type I)
```

```
## Analysis of Variance Table
##
## Response: hdl
##             Df  Sum Sq Mean Sq F value   Pr(>F)
## I(G2)        1  914.13  914.13 10.6768 0.003853 **
## I(G3)        1    3.21    3.21  0.0375 0.848394
## I(wt)        1  172.99  172.99  2.0205 0.170597
## I(G2 * wt)   1  317.97  317.97  3.7138 0.068292 .
## I(G3 * wt)   1  187.09  187.09  2.1851 0.154925
## Residuals   20 1712.36   85.62
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
(pval = 1-pf(q = (317.97+187.09)/2/85.62, df1 = 2, df2 = 20))
```

```
## [1] 0.07542134
```

Change ordering of covariates

```r
m3 = lm(hdl~I(wt)+I(G2*wt)+I(G3*wt)+I(G2)+I(G3))
anova(m3) #Sequential SS (type I)
```

```
## Analysis of Variance Table
##
## Response: hdl
##             Df  Sum Sq Mean Sq F value  Pr(>F)
## I(wt)        1  401.13  401.13  4.6851 0.04270 *
## I(G2 * wt)   1  446.89  446.89  5.2196 0.03339 *
## I(G3 * wt)   1  212.39  212.39  2.4807 0.13094
## I(G2)        1  509.73  509.73  5.9536 0.02412 *
## I(G3)        1   25.24   25.24  0.2947 0.59320
## Residuals   20 1712.36   85.62
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
(pval = 1-pf(q = (509.73+25.24)/2/85.62, df1 = 2, df2 = 20))
```

```
## [1] 0.06596391
```

SS test Alternative 1: GLH formulation (slopes)

```
(Contrast.T = matrix(c(0,0,0,0,1,0,0,0,0,0,0,1),byrow=T,nrow=2))
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    0    0    0    0    1    0
## [2,]    0    0    0    0    0    1
```

```
car::linearHypothesis(model=m2,hypothesis.matrix=Contrast.T,rhs=c(0,0))
```

```
## Warning in printHypothesis(L, rhs, names(b)): one or more coefficients in th
##      arithmetic operators in their names;
##   the printed representation of the hypothesis will be omitted
```

```
## Linear hypothesis test
##
## Hypothesis:
##
##
## Model 1: restricted model
## Model 2: hdl ~ I(G2) + I(G3) + I(wt) + I(G2 * wt) + I(G3 * wt)
##
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     22 2217.4
## 2     20 1712.4  2    505.05 2.9495 0.07542 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

SS test Alternative 1: GLH formulation (intercepts)

```
(Contrast.T = matrix(c(0,1,0,0,0,0,0,0,1,0,0,0),byrow=T,nrow=2))
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    0    1    0    0    0    0
## [2,]    0    0    1    0    0    0
```

```
car::linearHypothesis(model=m2,hypothesis.matrix=Contrast.T,rhs=c(0,0))
```

```
## Linear hypothesis test
##
## Hypothesis:
## I(G2) = 0
## I(G3) = 0
##
## Model 1: restricted model
## Model 2: hdl ~ I(G2) + I(G3) + I(wt) + I(G2 * wt) + I(G3 * wt)
##
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     22 2247.3
## 2     20 1712.4  2    534.97 3.1242 0.06596 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

SS test Alternative 2: ANOVA of nested models (slopes)

```r
anova(
  lm(hdl~I(G2)+I(G3)+I(wt)+I(G2*wt)+I(G3*wt)),
  lm(hdl~I(G2)+I(G3)+I(wt))
)
```

```
## Analysis of Variance Table
##
## Model 1: hdl ~ I(G2) + I(G3) + I(wt) + I(G2 * wt) + I(G3 * wt)
## Model 2: hdl ~ I(G2) + I(G3) + I(wt)
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     20 1712.4
## 2     22 2217.4 -2   -505.05 2.9495 0.07542 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

SS test Alternative 2: ANOVA of nested models (intercepts)

```r
anova(
  lm(hdl~I(G2)+I(G3)+I(wt)+I(G2*wt)+I(G3*wt)),
  lm(hdl~I(wt)+I(G2*wt)+I(G3*wt))
)
```

```
## Analysis of Variance Table
##
## Model 1: hdl ~ I(G2) + I(G3) + I(wt) + I(G2 * wt) + I(G3 * wt)
## Model 2: hdl ~ I(wt) + I(G2 * wt) + I(G3 * wt)
##   Res.Df    RSS Df Sum of Sq      F  Pr(>F)
## 1     20 1712.4
## 2     22 2247.3 -2   -534.97 3.1242 0.06596 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```