DA410 Assignment 3

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# Homework 3

## 6.27

Baten, Tack, and Baeder (1958) compared judges’ scores on fish prepared by three methods. Twelve fish were cooked by each method, and several judges tasted fish samples and rated each on four variables: = aroma, = flavor, = texture, and = moisture. The data are in Table 6.17. Each entry is an average score for the judges on that fish.

fish <-   
 readr::read\_table2(file = here::here("/assignment03/T6\_17\_FISH.DAT"),  
 col\_names = FALSE) %>%   
 select(X1:X5) %>%   
 mutate(X1 = factor(X1))

## Parsed with column specification:  
## cols(  
## X1 = col\_double(),  
## X2 = col\_double(),  
## X3 = col\_double(),  
## X4 = col\_double(),  
## X5 = col\_double(),  
## X6 = col\_character()  
## )

head(fish,10)

## # A tibble: 10 x 5  
## X1 X2 X3 X4 X5  
## <fct> <dbl> <dbl> <dbl> <dbl>  
## 1 1 5.4 6 6.3 6.7  
## 2 1 5.2 6.5 6 5.8  
## 3 1 6.1 5.9 6 7   
## 4 1 4.8 5 4.9 5   
## 5 1 5 5.7 5 6.5  
## 6 1 5.7 6.1 6 6.6  
## 7 1 6 6 5.8 6   
## 8 1 4 5 4 5   
## 9 1 5.7 5.4 4.9 5   
## 10 1 5.6 5.2 5.4 5.8

### (a)

Compare the three methods using all four MANOVA tests.

manova.data <- manova(cbind(X2 ,X3, X4, X5) ~ X1,  
 data=fish)  
  
broom::tidy(manova.data)

## # A tibble: 2 x 7  
## term df pillai statistic num.df den.df p.value  
## <chr> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 X1 2 0.860 5.84 8 62 0.0000146  
## 2 Residuals 33 NA NA NA NA NA

#### Wilks’ test

fish.lambda <- summary(manova.data, test = "Wilks")  
fish.lambda

## Df Wilks approx F num Df den Df Pr(>F)   
## X1 2 0.22449 8.3294 8 60 1.609e-07 \*\*\*  
## Residuals 33   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Wilks’ is low, so we can reject .

#### Pillai test

fish.pillai <- summary(manova.data, test = "Pillai")  
fish.pillai

## Df Pillai approx F num Df den Df Pr(>F)   
## X1 2 0.85987 5.845 8 62 1.465e-05 \*\*\*  
## Residuals 33   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Pillai test is low, so we can reject .

#### Roy test

fish.roy <- summary(manova.data, test = "Roy")  
fish.roy

## Df Roy approx F num Df den Df Pr(>F)   
## X1 2 2.9515 22.874 4 31 7.077e-09 \*\*\*  
## Residuals 33   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

#roy value is 137.168, which we convert...  
2.9515/(1+2.9515)

## [1] 0.7469315

We can reject for Roy as well.

#### Hotelling-Lawley test:

fish.hotel <- summary(manova.data, test = "Hotelling-Lawley")  
fish.hotel

## Df Hotelling-Lawley approx F num Df den Df Pr(>F)   
## X1 2 3.0788 11.161 8 58 2.161e-09 \*\*\*  
## Residuals 33   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

for Hotelling-Lawley test is also low, so that can be rejected.

summary.aov(manova.data)

## Response X2 :  
## Df Sum Sq Mean Sq F value Pr(>F)  
## X1 2 1.0506 0.52528 1.2928 0.288  
## Residuals 33 13.4083 0.40631   
##   
## Response X3 :  
## Df Sum Sq Mean Sq F value Pr(>F)   
## X1 2 4.88 2.44000 9.4953 0.000553 \*\*\*  
## Residuals 33 8.48 0.25697   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Response X4 :  
## Df Sum Sq Mean Sq F value Pr(>F)   
## X1 2 2.3822 1.19111 3.3863 0.04596 \*  
## Residuals 33 11.6075 0.35174   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Response X5 :  
## Df Sum Sq Mean Sq F value Pr(>F)  
## X1 2 0.8106 0.40528 1.2658 0.2954  
## Residuals 33 10.5658 0.32018

## 6.28

Table 6.18 from Keuls et al. (1984) gives data from a two-way (fixed-effects) MANOVA on snap beans showing the results of four variables: = yield earliness, = specific leaf area (SLA) earliness, = total yield, and = average SLA. The factors are sowing date (S) and variety (V).

snapbeans <-   
 readr::read\_table2(file = here::here("/assignment03/T6\_18\_SNAPBEAN.DAT"),  
 col\_names = FALSE) %>%   
 select(X1:X7) %>%   
 rename(S = X1,  
 V = X2,  
 pl = X3,  
 y1 = X4,  
 y2 = X5,  
 y3 = X6,  
 y4 = X7) %>%   
 mutate(S = factor(S),  
 V = factor(V),  
 pl = factor(pl))

## Parsed with column specification:  
## cols(  
## X1 = col\_double(),  
## X2 = col\_double(),  
## X3 = col\_double(),  
## X4 = col\_double(),  
## X5 = col\_double(),  
## X6 = col\_double(),  
## X7 = col\_double(),  
## X8 = col\_logical()  
## )

head(snapbeans, 5)

## # A tibble: 5 x 7  
## S V pl y1 y2 y3 y4  
## <fct> <fct> <fct> <dbl> <dbl> <dbl> <dbl>  
## 1 1 1 1 59.3 4.5 38.4 295  
## 2 1 1 2 60.3 3.5 38.6 302  
## 3 1 1 3 60.9 5.3 37.2 318  
## 4 1 1 4 60.6 5.8 38.1 345  
## 5 1 1 5 60.4 6 38.8 325

manova.beans <- manova(cbind(y1 ,y2, y3, y4) ~ S \* V,  
 data=snapbeans)  
  
manova.beans

## Call:  
## manova(cbind(y1, y2, y3, y4) ~ S \* V, data = snapbeans)  
##   
## Terms:  
## S V S:V Residuals  
## resp 1 728.79 124.52 30.29 11.90  
## resp 2 192.87 5.69 5.12 14.40  
## resp 3 747.78 8.40 5.87 13.66  
## resp 4 33469.38 8188.23 1887.77 7245.60  
## Deg. of Freedom 3 2 6 48  
##   
## Residual standard errors: 0.4978286 0.5477986 0.5333854 12.28617  
## Estimated effects may be unbalanced

### (a)

Test for main effects and interaction using all four MANOVA statistics.

#### Wilks’ Test

(this is a kind of test to measure if means are equal)

beans.lambda <- summary(manova.beans, test = "Wilks")  
beans.lambda

## Df Wilks approx F num Df den Df Pr(>F)   
## S 3 0.000645 149.831 12 119.35 < 2.2e-16 \*\*\*  
## V 2 0.065300 32.775 8 90.00 < 2.2e-16 \*\*\*  
## S:V 6 0.137947 5.039 24 158.20 1.611e-10 \*\*\*  
## Residuals 48   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Wilks for S is low, reject . Wilks for V is low, reject . Wilks for the S\*V interaction is low, reject .

#### Pillai test

beans.pillai <- summary(manova.beans, test = "Pillai")  
beans.pillai

## Df Pillai approx F num Df den Df Pr(>F)   
## S 3 2.3568 43.052 12 141 < 2.2e-16 \*\*\*  
## V 2 1.1070 14.256 8 92 2.564e-13 \*\*\*  
## S:V 6 1.3213 3.946 24 192 3.912e-08 \*\*\*  
## Residuals 48   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

is rejected in Pillai’s test as well.

#### Roy test

beans.roy <- summary(manova.beans, test = "Roy")  
  
#roy values are 137.168, 11.445, and 2.649  
S <- 137.168/(1+137.168)  
V <- 11.445/(1+11.445)  
SV <- 2.649/(1+2.649)  
  
S

## [1] 0.9927624

V

## [1] 0.9196464

SV

## [1] 0.7259523

is rejected with Roy’s test.

#### Hotelling-Lawley test:

beans.hotel <- summary(manova.beans, test = "Hotelling-Lawley")  
beans.hotel

## Df Hotelling-Lawley approx F num Df den Df Pr(>F)   
## S 3 142.304 517.83 12 131 < 2.2e-16 \*\*\*  
## V 2 11.675 64.21 8 88 < 2.2e-16 \*\*\*  
## S:V 6 3.450 6.25 24 174 8.671e-14 \*\*\*  
## Residuals 48   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

And finally, we reject with Hotelling-Lawley test.