# MAT4375 HW#2, 1999

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- Problem 6.7
- Problem 6.8
- Problem 6.13
- Problem 6.14
- Problem 7.21

Due to html limitations, ``X- bar'' will be noted  $\underline{X}$ . From the fourth edition of Johnson and Wichern

Problem 6.7 Follow example 6.4. Here  $n_1 = 45$ ,  $n_2 = 45$ ,

$$\underline{x}_{1} = \begin{bmatrix} 204.4 \\ 556.6 \end{bmatrix}$$
$$\underline{x}_{2} = \begin{bmatrix} 130.0 \\ 355.0 \end{bmatrix}$$
$$S_{1} = \begin{bmatrix} 13825.3 & 23823.4 \\ 23823.4 & 73107.4 \end{bmatrix}$$
$$S_{2} = \begin{bmatrix} 8632.0 & 19616.7 \\ 19616.7 & 55964.5 \end{bmatrix}$$

The test is Given by Result 6.2 page 305: Reject H<sub>0</sub> if

$$T^{2}:=[\underline{X}_{1}-\underline{X}_{2}-(\mu_{1}-\mu_{2})]'[(1/n_{1}+1/n_{2})S_{\text{pooled}}]^{-1}[\underline{X}_{1}-\underline{X}_{2}-(\mu_{1}-\mu_{2})] > ((n_{1}+n_{2}-2)/(n_{1}+n_{2}-p-1))F_{\alpha}(p, n_{1}+n_{2}-p-1)$$
  
Here the critical value is  $c^{2} = 6.26$  and

$$S_{\text{pooled}} = \begin{bmatrix} 10963.7 & 21505.5 \\ 21505.5 & 63661.3 \end{bmatrix}.$$

Thus  $T^2 \cong 16.1 > 6.26$  and we reject H<sub>0</sub>. The linear combination of components most responsible for rejection is proportional to

$$\mathrm{S}^{-1}_{\mathrm{pooled}}(\underline{X}_{1},\underline{X}_{2}) \cong \begin{bmatrix} 0.0017 \\ 0.0026 \end{bmatrix}.$$

Problem 6.8 (a)

$$\underline{\mathbf{x}} = \begin{bmatrix} 3.75 \\ 9.5 \end{bmatrix}$$
$$\underline{\mathbf{x}}_{1} = \begin{bmatrix} 6 \\ 8 \end{bmatrix} \mathbf{n}_{1} = 5$$
$$\underline{\mathbf{x}}_{2} = \begin{bmatrix} 2 \\ 4 \end{bmatrix} \mathbf{n}_{1} = 3$$
$$\underline{\mathbf{x}}_{3} = \begin{bmatrix} 3 \\ 2 \end{bmatrix} \mathbf{n}_{1} = 4$$

$$SSCP_{tot} = (X - [\underline{X}]_{2 \times 12})(X - [\underline{X}]_{2 \times 12})' = \begin{bmatrix} 54 & 35 \\ 35 & 102 \end{bmatrix}$$

$$SSCP_{tr} = \sum_{i=1}^{3} ([\underline{X}_i] - [\underline{X}]_{2 \times n(i)}) ([\underline{X}_i] - [\underline{X}]_{2 \times n(i)})' = \begin{bmatrix} 36 & 48 \\ 48 & 84 \end{bmatrix}$$

$$SSCP_{err} = \sum_{j=1}^{n} (X_j - \underline{X}_{i(j)}) (X_j - \underline{X}_{i(j)})' = \begin{bmatrix} 18 & -13 \\ -13 & 18 \end{bmatrix}$$

where i(j) is the group of subject j. The degrees of freedom are 11, 2 and 9, respectively.

(b)

Here  $\Lambda^* = 0.035$ , so using Table 6.3 for p = 2 and  $g \ge 2$ 

$$(8/2)\left(\left(1-\sqrt{\Lambda^*}\right)/\sqrt{\Lambda^*}\right) = 17$$

and  $17 > F_{0.01}(2(3-1), 2(12-3-1))$ . We reject. Bartlett's correction rejects if

$$-(11-5/2)\ln\Lambda^* > \chi^2_{0.01}(4) = 13.28.$$

Here the left side is 28.5 > 14.

## $Problem \ 6.13 \ {\rm For \ component \ \#1},$

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Similarly for componenet #2. Thus

$$SS_{tot} = \begin{bmatrix} 220 & 227 \\ 227 & 440 \end{bmatrix}$$
$$SS_{\mu} = \begin{bmatrix} 12 & 36 \end{bmatrix}$$

$$\begin{bmatrix} 36 & 108 \end{bmatrix}$$
$$SS_{1} = \begin{bmatrix} 104 & 148 \\ 148 & 248 \end{bmatrix}$$
$$SS_{2} = \begin{bmatrix} 90 & 51 \\ 51 & 54 \end{bmatrix}$$
$$SS_{err} = \begin{bmatrix} 14 & -8 \\ -8 & 30 \end{bmatrix}$$

The factor 1 effect test rejects if

$$-((g-1)(b-1)-(p+1-(g-1))/2) \ln(|SS_{res}|/|SS_1+SS_{res}|) > \chi^2_{\alpha}((g-1)p)$$

and similarly for factor 2. Both reject.

### Problem 6.14

Part (a) repeats the work of 6.13. The general MANOVA formulae give

$$SS_{1} = \begin{bmatrix} 496 & 184 \\ 184 & 208 \end{bmatrix} df = 2$$
$$SS_{2} = \begin{bmatrix} 36 & 24 \\ 24 & 36 \end{bmatrix} df = 3$$
$$SS_{int} = \begin{bmatrix} 32 & 0 \\ 0 & 44 \end{bmatrix} df = 6$$
$$SS_{err} = \begin{bmatrix} 312 & -84 \\ -84 & 400 \end{bmatrix} df = 12$$

For part (c), the test of interactions rejects if

$$-(gb(n-1)-(p+1-(g-1)(b-1))/2) \ln(|SS_{res}|/|SS_{int}+SS_{res}|) > \chi^2_{\alpha}((g-1)(b-1)p)$$

This does not reject. We further conclude there is a factor 1 effect, but no factor 2 effect. The formulae for Bonferroni intervals is found on page 337, (6-59). The only interval that does not contain 0 is [3.2, 18.8] for  $\tau_{11}$ - $\tau_{31}$ .

### Problem 7.21

I like taking a log transform of the  $NO_2$  and  $O_3$  and fitting a quadratic in SOLAR to these. The residuals look okay. WIND does not seem to be needed.

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Ozone analysis

Nitrogen analysis

File translated from  $T_E X$  by  $\underline{T_T H}$ , version 1.90. On 24 Mar 1999, 14:42.