

THE UNIVERSITY OF CHICAGO
Graduate School of Business
Business 41912-01, Spring Quarter 2008, Mr. Ruey S. Tsay

Solutions to Homework Assignment #3

1. Problem 6.18 of the textbook, p.343.

Answer: Log-transformation is used in the analysis. (a) Apply the **manova**. The approximate F-test statistic is 27.118 (the Hotelling T^2 statistic is 85.1) with p-value close to zero. The equality of the two population mean vectors is rejected at $\alpha = 0.05$. (b) Based on the pooled covariance matrix, the most responsible linear combination is given by $(-525, -105, 811)$. The 95% Bonferroni intervals are $[0.0769, 0.2736]$, $[0.069, 0.222]$, $[0.147, 0.328]$ for the mean differences between the two populations, respectively.

2. Problem 6.19 of the textbook, p.343.

Answer: (a) From **manova**, the approximate F test statistic is 16.376 with p-value close to zero so that the equality in mean vectors is rejected at the 1% level. The T^2 is 50.9. (b) The most responsible linear combination is given by $(3.58, -1.88, -4.47)$. (c) The Bonferroni 99% simultaneous C.I. for the differences in means are $[-1.14, 5.37]$, $[-6.38, 1.08]$, and $[-12.80, -4.35]$, respectively. From the intervals, the third component seems to be very different. (d) With Cases 9 and 21 removed, we repeated the same analysis. The approximate F test statistic is 16.83, which remains highly significant. The corresponding T^2 is 52.38. The Bonferroni simultaneous C.I.s continue to show major difference in the third component.

3. Problem 6.22 of the textbook, p.347.

Answer: (a) The approximate F test statistic is 22.59 with p-value close to zero so that the gender equality in measurements is rejected at $\alpha = 0.05$. The T^2 is 96.37. (b) The simultaneous 95% Bonferroni C.I.s for differences in means are $[0.0160, 0.1512]$, $[-0.88, 1.18]$, $[0.977, 1.768]$, and $[6.65, 15.88]$, respectively. (c) There is a possibility of some serial dependence in the measurements. In addition, volunteers might represent those who exercise more regularly.

4. Problem 6.25 of the textbook, p.347.

Answer: Square-root transformation is used in the analysis. (a) From **manova**, the approximate F test statistic is 14.602 with p-value close to zero so that the equality of mean vectors is rejected at the 5% level. We calculate the 95% simultaneous Bonferroni C.I.s for the differences in means using pairs of two populations. For Wilhelm and

Sub-Mulina, the C.I.s are [-0.837, 0.302], [-0.364, 2.203], [-0.361, 0.280], [-0.270, 0.372], [0.325, 1.957], respectively.

For Sub-Mulina and Upper, the C.I.s are [-0.989, -0.208], [0.177, 1.889], [-0.50248, -0.00583], [0.196, 0.612], [-0.605, 0.409], respectively. From the intervals, it seems the differences come from components 1 and 3.

5. Problem 6.31 of the textbook, p.353.

Answer: The two-way MANOVA table is given below:

```
> mm=manova(y~fac1+fac2+fac1*fac2)
> mm
Call:
  manova(y ~ fac1 + fac2 + fac1 * fac2)

Terms:
              fac1      fac2 fac1:fac2 Residuals
resp 1          0.7008  196.1150  205.1017  104.2050
resp 2        162.0675 1089.0150  780.6950  352.1050
resp 3          72.5208  284.1017   85.9517   94.8350
Deg. of Freedom          1          2          2          6

Residual standard error: 4.167433 7.660559 3.975655
Estimated effects may be unbalanced
> summary(mm,"Wilks")
              Df   Wilks approx F num Df den Df   Pr(>F)
fac1           1  0.1065  11.1843     3    4 0.020502 *
fac2           2  0.0124  10.6191     6    8 0.001928 **
fac1:fac2      2  0.0743   3.5582     6    8 0.050794 .
Residuals     6
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From which, there is no interaction, but the main effects of location and variety are significant at the 5% level. (b) Since the sample size is small, the residuals analysis is not informative. At least, I did not see any major violation. (c) Overall, the test indicates no interaction. However, univariate ANOVA tables of the components show that interaction between location and variety is significant at the 5% level for X_1 (Yield) and X_2 (Sound mature kernels). (d) Again, since the sample size is small, the 95% simultaneous Bonferroni C.I.s for differences in means of two populations are not informative. They are given below: (i) Pop. 1 vs II and III combined [-40.57, 9.77], [-88.5, 14.8], and [-53.9, 30.5] (ii) Pop. I and II combined vs Pop.III. [-64.1, 47.8], [-144.2, 97.9], [-51.3, 26.3]. (iii) Pop. I and III combined vs Pop. II. [-65.0, 50.5], [-154, 127], [-60.7, 62.3].