STA 6167 – Project 2

Part 1: Response Surface – Biodiesel Synthesis from Waste Canola Oil

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Dataset: canola_biodiesel.dat

Source: S. Lee, D. Posarac, N. Ellis (2012). "An Experimental Investigation
of Biodiesel Synthesis from Waste Canola Oil Using Supercritical Methanol,"
Fuel, Vol. 91, pp. 229-237.

Description: Experiment relating 3 factors to yield of methyl ester
from waste canola oil: Time(15,30,45min), Temperature(240,255,270C),
and Methanol/Oil weight ratio (1,1.5,2)

Variables/Columns
Run#   7-8
Coded Time    15-16
Coded Temp    23-24
Coded methanol/oil   31-32
Time        37-40
Temp        45-48
methanol/oil    53-56
yield (%)    58-64
```

- Fit a second-order response surface, relating yield of methyl ester (Y, %) to the factors Time, Temperature, and Methanol/Oil ratio.
    - What fraction of the variation in yield is explained by the model?
    - What combination of levels of Time, Temp, and M/O give the maximum yield based on the response surface (not based on simply the raw data)?
- Assuming that not all regression coefficients are significant, fit a reduced model, eliminating the non-significant term(s). Note that if a second-order term is kept, all first order terms within it should be kept.
    - What fraction of the variation in yield is explained by the model?
    - Test whether all terms that were removed have all coefficients equal to 0 (Complete/Reduced F-test)
    - Based on the F-test for lack of fit, is this model appropriate?

Part 2: Comparison of 3 Temperatures and 2 Pressures on Espresso Foaming

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Dataset: espresso2.csv

Source: P. Masella, L. Guerrini, S. Spinelli, L. Calamai, P. Spugnoli,
F. Illy, A. Parenti (2015). "A New Espresso Brewing Method,"
Journal of Food Engineering, Vol. 146, pp. 204-208.

Descrption: Comparison of foam index (Y, in %) for 3 temperatures (75C,85,90)
and 2 extraction pressures (15bar and 20).
9 replicates/treatment.
Data simulated to match means and SDs

Variables:
foamIndx
trt_id
tempC
prssBar
```

- Run the additive 2-Way ANOVA.
    - Test for main effects of Temperature and Extraction Pressure.

    - Use Tukey's and Bonferroni's methods to compare all pairs of Temperatures
- Run the interaction 2-Way ANOVA
    - Test for interaction effects.
    - Use Tukey's method to compare all pairs among the 6 treatments (Hint: fit a 1-Way ANOVA with the factor trt_id).

Part 3: 2-Factor ANOVA Run as a Randomized Block Design

- Response: Y=Hairiness index of worsted yarns.
- Factor A: Twist level: 373tpm, 563tpm, 665tpm
- Factor B: Test Speed: 25m/min, 100m/min, 400m/min
- Blocking Factor: Bobbin: 1,2,3,4,5,6

ANOVA

Source of Variation	DF	SS	MS	F_obs	F(.05)	P-value
Twist Level						
Test Speed						
TL x TS						
Bobbin						
Error						
Total						

Are we justified in assuming additive effects for twist level and test speed? ____

Comparisons among twist levels and test speeds:

MSE = _____ df_E = ___ # trts=C= _____ Reps for each level _____

Tukey's HSD =

Bonferroni's MSD =

Twist Levels	Mean1	Mean2	Diff	Conclude
373 - 563				
373 - 665				
563 - 665				
Test Speeds				
25 - 100				
25 - 400				
100 - 400				

Part 4: Unbalanced 2-Way (Fixed Effects) ANOVA

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Dataset:  celebrityendorse_attention.csv

Source: P.-S. Wei, H.-P. Lu (2013). "An examination of the Celebrity
Endorsements and Online Customer Reviews Influence Female Consumers'
Shopping Behavior," Computers in Human Behavior, Vol. 29, pp. 193-201.

Description: Experiment with 2-factors: Product (1=Shoes, 2=Ink Toner)
and Endorser (1=Celebrity, 2=Online customer). Completely Randomized
(Between Subjects) Design. Data simulated to match trt means and SDs.
Response is subjects' attention score (average of 3 1-5 responses).

Variable names:
trt_group   /* 1=shoes/celeb, 2=shoes/online, 3=toner/celeb, 4=toner/online
product     /* 1= shoes, 2=ink toner */
endorser   /* 1=celebrity, 2=online customer  */
shoe       /* 1=shoe, 0=toner   */
celebrity    /* 1=celebrity, 0=online customer   */
attention    /* response variable */
```

- Fit the 2-Way ANOVA model as a regression model with $X_1 = 1$ if shoes, -1 if Toner; and $X_2 = 1$ if Celebrity, -1 if online customer. Test for interaction, and main effects.
- Use the **aov** function in R. Test for main interaction and main effects. (use the contrasts=c("contr.sum", "contr.poly") option)
- Compare the results.

Part 5: 2-Way (Random Effects) ANOVA

A study was conducted to measure the repeatability and reproducibility of measurements of manufactured parts by operators. There were a = 12 parts, b = 3 operators, and each operator measured each part n = 4 on 4 occasions (replicates). In experiments such as these, both parts and operators are random factors.

- Obtain the Analysis of Variance
- Test $H_0^{AB}: \sigma_{ab}^2 = 0$ $H_0^{A}: \sigma_{a}^2 = 0$ $H_0^{B}: \sigma_{b}^2 = 0$
- Give Point estimates of each of the variance components
- Repeatability Variance is V{Repeatability} = V{ε}, give its estimate
- Part Variance is V{P} = V{α}, give its estimate
- Reproducibility Variance is V{Reproducibility} = V{β} + V{αβ}, give its estimate
- Measurement System Variance is V{MS} = V{Reproducibility} + V{Repeatability}, give its estimate
- Total Variance is V{T} = V{P} + V{MS}, give its estimate
- %Reproducibility and Repeatability = %R&R = 100*sqrt(V{MS}/V{T}), give its estimate