Maker

Exam 3 (Final exam) Stat 502 Spring 2016

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Question 1 (15 points)

An experiment compares four different mixtures of the components used in the manufacturing of rocket propellant. To compare the four mixtures, five different samples of propellant are prepared from each mixture and readied for testing. Each of five investigators is randomly assigned one sample of each of the four mixtures and asked to measure the propellant thrust.

a. (5 points) Identify the blocks and treatments for this experimental design.

The treatment: Mixtures

Blocks: Investigators

b. (5 points) Explain why this is a randomized complete block design.

Within a block we want all the treatment levels or treatment combinations to be represented. With 5 investigators each getting one sample of each of the four mixtures, we have 5 blocks of 4 positions. The key element is that each treatment level or treatment combination appears in each block, and were assigned at random within each block.

c. (5 points) Why would this design be preferable to a completely randomized design?

The F statistic for the treatment increases with blocking. This sort of increase in the F statistic often means the difference between rejecting or failing to reject a Null Hypothesis.

This happens because the blocking leads to reduction in MSE due to partition in SSE for the normal CRD into SSBlock + SSE for RCBD

The potential reduction in SSE by blocking is to some degree offset by losing degrees of freedom for the blocks, but more often than not, is worth it in terms of the improvement in the calculated F statistic.

Question 2 (20 points)

Burdick and Graybill (1992, pp. 11-12) described a quality control experiment designed to study the sources of variability in the length of window screens. It is desired to determine the contribution of the variability in the final product that is due to operators, machines, and the operator x machine interaction.

Three operators and four machines are randomly selected from the available operators and machines in the company and each operator makes two screens on each of the selected machines.

a. (5 points) This is a two-way crossed classification. For each of the two factors, indicate if it is appropriate to treat it as fixed or random.

This is a 2-way crossed classification with the treatments:

Operator: Random Effect: Study states that 3 operators are randomly selected from the available operators in the company

Machine: Random Effect: Study states that 4 machines are randomly selected from the available machines in the company

b. (15 points) Use the ANOVA table below to provide estimates of all the components of variance.

Source	SS	DF	MS
Operator	0.1425	2	0.0713
Machine	0.7112	3	0.2371
Interaction	4.1975	6	0.6996
Error	3.7750	12	0.3146

You are given that the expected mean squares are:

$$\text{EMS(operator)} = \sigma^2 + n\sigma^2_{OPER\ X\ MAC} + nb\sigma^2_{OPER}$$
$$\text{EMS(Machine)} = \sigma^2 + n\sigma^2_{OPER\ X\ MAC} + na\sigma^2_{MAC}$$
$$\text{EMS(Operater x Machine)} = \sigma^2 + n\sigma^2_{OPER\ X\ MAC}$$
$$\text{EMS(Error)} = \sigma^2$$

where a = 3, b = 4 and n = 2.

Source	EMS	Variance Components
Error	$\sigma^2 = 0.3146$	0.3146
Interaction Operater x Machine	$\sigma^2 + 2\sigma^2_{OPER\ X\ MAC} = 0.6996$ $\sigma^2_{OPER\ X\ MAC} = (0.6996 - 0.3146) / 2$	0.1925
Operator	$\sigma^2 + 2\sigma^2_{OPER\ X\ MAC} + 8\sigma^2_{OPER} = 0.0713$ $\sigma^2_{OPER} = (0.0713 - 0.6996) / 8$	-0.07854
Machine	$\sigma^2 + 2\sigma^2_{OPER\ X\ MAC} + 6\sigma^2_{MAC} = 0.2371$ $\sigma^2_{MAC} = (0.2371 - 0.6996) / 6$	-0.07708

Question 3 (18 points)

Each of the following is a description of a three factor study. Identify the three factors and state if they are random or fixed.
Also, state the relationship between the three factors. For example, labeling the three factors as A, B and C, some possible answers are:
A, B and C are all crossed;
B is nested in A, and C is nested in both A and B;
A and B are crossed and C is nested in both A and B, etc.

a. (6 points) Thirty randomly selected subjects were tested in an experiment on the effects of sunglasses on visual acuity. The tests were conducted using all possible combinations of two types of sunglasses and five different lighting conditions. In addition, each subject was tested under three different levels of initial light adaptation. A single visual acuity score was obtained from each subject under each level of adaptation.

Factors are:

A	Type of Sunglass	Fixed
B	different lighting conditions	Fixed
C	initial light adaptation	Fixed

A, B and C are all crossed;

We also have for the C factor a cross over design with repeated measures since the study states that each subject was tested under three different levels of initial light adaptation and a single visual acuity score was obtained from each subject under each level of adaptation.

b. (6 points) Six randomly selected first-grade teachers were each assigned 12 randomly selected pupils. Each teacher taught the pupils two subjects, reading and arithmetic. At the end of the year all six classes were given the same standard tests in these two subjects. The data were the test scores of the individual pupils in each of the two subjects.

Factors are:

A	First-grade teachers	Random
B	Subjects	Fixed

C	Pupils	Random

A and B are crossed. C is nested within A.

c. (6 points) Two cancer treatments were being compared. Thirty randomly selected hospitals participated in the experiment, with ten hospitals using each treatment, and ten using traditional treatments (as a control). In each hospital, fifteen patients were treated, each having one of three types of cancer (i.e., there were five patients with each type of cancer). The health of each patient was rated on a ten-point scale after one week, two weeks, and three weeks of treatment.

Factors are:

A	Cancer treatment	Fixed
B	Hospital	Random
C	Type of cancer	Fixed

B is nested in A also stated as B(A), and C is crossed with B(A)

Question 4 (12 points)

Consider an experimental design in which each experimental unit receives multiple treatments over the course of the experiment.

a. (5 points) Such a design is characterized as a ___ ***cross-over design***, a special case of repeated measures_____ design.

b. (7 points) In this design it is important to have a ___ ***wash-out period***_____ between treatment applications to prevent (or minimize) ___ ***carry-over effects***_____.

Question 5 (15 points)

The following summary was produced for a repeated measures study:

Information Criteria	CS	AR(1)	(UN)
-2 Res Log Likelihood	210.7	210.4	212.9
AIC (smaller is better)	222.2	214.4	216.9
AICC (smaller is better)	225.1	214.8	217.3
BIC (smaller is better)	226.9	216.0	218.4

a. (5 points) What covariance structure would you recommend on the basis of this output?

When using the AICC criterion we find that AR(1) is recommended because of its smallest value. Infact even AIC and BIC also point to the same recommendation

b. (5 points) What would be required in order for the data analyst to use the covariance structure identified as the 'best' in part (a)?

The AR(1) covariance structure is only applicable for evenly spaced time intervals for the repeated measure.

c. (5 points) What alternative could be considered as a covariance structure if the conditions you specified in part (b) are not met?

When time intervals are not evenly spaced, a covariance structure equivalent to the AR(1) is the spatial power (SP(POW)).

Preamble for Questions 6-7: Two different studies are conducted by two different research contractors. The objective is to assess the effect of the computer platform (PC *vs* MAC) on the time to complete two different Tasks (document *vs* math).

Question 6 (8 points)

The first contractor designs an experiment in which in which 4 computer classrooms are chosen at random, and by random assignment 2 are set up with PC machines and two are set up with MACs. There are 20 students assigned at random to each of the classrooms. Within each classroom, 10 students are randomly assigned to complete the document task, and 10 are randomly assigned to complete the math task. The time it takes each student to complete the task is recorded as the dependent variable.

a. (4 points) Identify (i.e. name) the treatment design

A two factor factorial with computer platform at 2 levels and Tasks at 2 levels.

They are all fixed effects.

b. (4 points) Identify (i.e. name) the randomization design

A split plot in a completely randomized design (CRD). It is a split plot because there are two different types of experimental units (EU's) being used: the class is the EU for the assignment of a computer platform treatment level. The experimental unit for the task is the set of students that have already been assigned the computer platform treatment. It is a split plot in a CRD because the computer platform treatment was assigned to classes completely at random (i.e., two of the four classes were randomly assigned the PC, and two were randomly assigned the MAC)

Question 7 (12 points)

The second company designs an experiment in which 4 computer classrooms are chosen at random, and by random assignment 2 are set up with PC machines and two are set up with MACs. There are 20 students assigned at random to each of the classrooms. Each student is as assigned one of two sequences to complete the tasks, and each student in a classroom completes each task in the order determined by the sequence. The time it takes each student to complete the task is recorded as the dependent variable.

a. (4 points) Identify (i.e. name) the treatment design

A two factor factorial with computer platform at 2 levels, Tasks at 2 levels with a Cross-over design.

In this 2 treatment level case, the study has included a 'sequence' categorical variable in the model to assess the presence of a carry-over effect (If the sequence variable is significant, then a detectable carry-over effect exists)

They are all fixed effects.

b. (4 points) What feature of this experimental design is fundamentally different from the previous (question 6) design?

The fundamental difference is that there is a Cross-over design with repeat measures on the student. The study states that the student completes each task in the order determined by the assigned sequence and the time it takes to complete the task is recorded as the dependent variable.

So while in the previous design performed one task randomly assigned between Document or Math, in the second study each student performs both the tasks though they perform the tasks in different order based on the assigned sequence.

c. (4 points) What concern should you have about when the tasks are scheduled?

The complicated part of the cross-over design is the potential for carry-over effects. A carry-over effect is when the response to a particular treatment level (here task) has been influenced by the previous application of a different treatment level.

Avoiding carry-over effects is one solution to this potential problem - this is usually accomplished with a sufficient wash-out period. A washout period is a gap in time between the applications of the treatment levels (assignment of tasks) such that any residual effect of a previous treatment level has dissipated and there is no detectable carry-over effect.