

OLLSCOIL na hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

MBS DEGREE EXAMINATIONS, 1999 - 2000

RESEARCH METHODOLOGY - MG 525
PART A

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Time allowed: THREE hours

Answer FOUR questions.

All questions carry equal marks

**Mathematics Tables and New Cambridge Statistical Tables are available to all
Candidates**

Question 1.

(i) A garment making company wants to investigate the relationship between the age and annual maintenance costs of sewing machines. A sample of 16 machines reveals the following ages and maintenance costs during the past year.

| | | | | | | | | |
|------------------------|-----|----|----|-----|----|-----|----|----|
| Age (Years) x | 8 | 3 | 1 | 9 | 5 | 7 | 5 | 2 |
| Maintenance Cost (£) y | 109 | 75 | 21 | 135 | 67 | 125 | 71 | 52 |

Cont'd

| | | | | | | | | |
|------------------------|----|----|-----|----|----|----|-----|-----|
| Age (Years) x | 1 | 3 | 6 | 2 | 1 | 2 | 6 | 8 |
| Maintenance Cost (£) y | 25 | 70 | 126 | 58 | 30 | 47 | 120 | 105 |

Given the following calculations:

$$\bar{y} = 77.25$$

$$s_y = 1236$$

$$r = 0.921$$

$$b_0 = \bar{y} - b_1 \bar{x}$$

$$\Sigma xy = 6793$$

$$\bar{x} = 4.3125$$

$$s_x = 69$$

$$\Sigma(x^2) = 413$$

$$\Sigma(y_i - \hat{y}_i)^2 = 3313.97$$

$$(\Sigma x)^2 = 4761$$

Given that the assumptions underlying linear regression analysis are fulfilled and given also the partial printout (below) from the regression analysis:

| Predictor | Coeff | Stdev | t | p-value |
|-----------|--------|-------|------|---------|
| Age | 12.671 | 1.432 | 8.85 | 0.000 |

$$s = 15.39$$

Analysis of Variance

| Source | df | ss | ms | F-ratio | p-value |
|------------|----|-------|----|---------|---------|
| Regression | 1 | 18535 | | 78.3 | 0.000 |
| Error | | | | | |
| Total | | | | | |

Cont'd ...

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- (a) What is the regression equation?
 - (b) Determine if there is a significant linear relationship between the age and annual maintenance costs of the sewing machines.
 - (c) Complete the ANOVA table. What does the ANOVA table tell you?
 - (d) What is the value of the coefficient of determination? What does this tell you?
 - (e) What is the predicted maintenance cost
 - (i) for a 4-year old machine?
 - (ii) for a 12-year old machine?
- Comment on your results.
- (f) What are the assumptions underlying regression referred to above?

(75 marks)

- (ii) In hypothesis testing, what is meant by
 - (a) Type I error?
 - (b) Type II error?

(25 marks)

[Total 100 marks]

Question 2.

- (i) Scores obtained by employees on a manual dexterity test are normally distributed with a mean of 600 and a variance of 10,000.
 - (a) An employee is about to take the test. What is the probability that the employee's score will be 850 or more?
 - (b) What proportion of employees score between 450 and 700?
 - (c) Management has decided that employees whose scores are among the top 10% will be eligible for promotion to a higher paid job. What score must an employee obtain in order to be eligible for promotion?
 - (d) Suppose that management now decide to consider for promotion only those employees who achieve a score of 800 or more. What percentage of employees will now be eligible to be considered for promotion?

(35 marks) Cont'd ...

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(ii) Brightglo Fibres Ltd. is comparing the effects of 4 different processing methods on the strength of a particular type of synthetic fibre. They buy their raw material from four different suppliers, and a sample of each of the different suppliers' materials is subjected to each of the four different processing methods. The following table gives the strengths of 16 specimens prepared during one such experiment.

| | | Processing Methods | | | |
|----------------------------|----|--------------------|----|----|----|
| Raw Material Sources | S1 | A | B | C | D |
| | S2 | 11 | 10 | 13 | 14 |
| | S3 | 12 | 10 | 16 | 14 |
| | S4 | 16 | 17 | 18 | 18 |
| | | 17 | 15 | 18 | 18 |

An incomplete computer printout of the analysis of variance for this experiment is given below.

Analysis of Variance

| Source | ss | df | ms | F-ratio |
|-------------------|-------|----|----|---------|
| Processing Method | 87.69 | | | |
| Supplier | 29.69 | | | |
| Error | 9.06 | | | |
| Total | | | | |

- Complete the ANOVA table.
- Which is the blocking variable and which is the treatment variable in this experiment?
- Explain what the terms "treatment variable" and "blocking variable" mean.
- Develop the appropriate null hypotheses and alternative hypotheses, primary and secondary.
- Test your null hypotheses (primary and secondary) against the appropriate alternative hypotheses at $\alpha = 0.05$ and explain what these results mean.
- What conclusions do you think the management of the company can draw from these results?

(65 marks)

[Total 100 Marks]

Question 3.

(i) A researcher conducting research into present-day lifestyles has designed a number of questionnaires aimed at helping people take stock of their typical stress habits and patterns. One of the items in the questionnaire for women who are mothers includes the statement "I feel like I'm being pulled in lots of different directions by the needs and expectations of others." The respondent is asked to indicate the frequency with which the statement applies to her by selecting one of the three responses "usually", "sometimes" or "rarely".

A sample of 375 women who are mothers, comprising 100 executives, 150 clerical workers and 125 women who do not work outside the home complete the questionnaire. The results to the item described above is given in the following table:

| | Usually | Sometimes | Rarely |
|-------------------------------------|---------|-----------|--------|
| Executives | 25 | 60 | 15 |
| Clerical Workers | 80 | 60 | 10 |
| Not Working outside home | 60 | 40 | 25 |

On the basis of these data, can it be concluded that for women who are mothers, the three occupational groups, executives, clerical workers and women not employed outside the home, differ with respect to the frequency with which they feel they are pulled in lots of different directions by the needs and expectations of others? Use a significance level of 5% for your test.

(50 marks)

Cont'd ...

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- (ii) Twelve randomly selected employees take part in a study to assess the relationship between the employees' scores on a job aptitude test and supervisors' evaluation of the employees' subsequent job performance. The data are as follows:

| Employee Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------------------------|----|----|----|----|----|----|----|----|----|----|----|----|
| Aptitude test score | 13 | 41 | 72 | 24 | 57 | 99 | 84 | 36 | 92 | 63 | 31 | 75 |
| Supervisor's evaluation | 31 | 19 | 81 | 43 | 50 | 74 | 63 | 24 | 99 | 96 | 28 | 80 |

- (a) Compute an appropriate correlation coefficient and explain what this actually means with respect to the above data.
- (b) Indicate why you have chosen this particular correlation coefficient
- (c) Test whether the correlation coefficient you have calculated is significant at the 0.01 level and explain what this result means.

(50 marks)

[Total 100 marks]

Question 4.

(i) In a telephone survey, 224 adult respondents were asked to provide information regarding their practices and attitudes with respect to cigarette smoking. As part of the survey, respondents were asked to indicate their level of agreement with the statement "Cigarette smoking should be banned in restaurants." The following table shows the results classified according to the gender of the respondent.

| Gender | Level of Agreement | | | | Strongly Disagree |
|--------|--------------------|-------|---------|----------|-------------------|
| | Strongly Agree | Agree | Neutral | Disagree | |
| Female | 40 | 38 | 16 | 37 | 5 |
| Male | 16 | 25 | 11 | 25 | 11 |

Can we conclude on the basis of these data that in the sampled population, males and females differ with respect to their levels of agreement on the banning of cigarette smoking in restaurants? Use $\alpha = 0.05$.

(50 marks)

(ii) When computer packages for the Chi-square test are used for 2x2 contingency analysis, they usually give two values - without continuity correction and with continuity correction.

(a) Why is this?

(b) Which one would you advise using, and why?

(20 marks)

(iii) A floor covering manufacturer is seeking a carpeting material that will be heat resistant up to 120° Celsius. Two materials are being tested for heat tolerance. Simple random samples of 225 independently chosen specimen pieces are tested for each of the two materials. Thirty-six (36) specimens of one material and 45 specimens of the other material fail at temperatures below 120° Celsius. Can we conclude from these data that the two materials differ with respect to heat tolerance? Let $\alpha = 0.05$.

(30 marks)

[Total 100 marks]

Question 5.

(i) A market research firm wants to determine how successful its new, improved training programme for telephone interviewers is. After completing a training programme, the telephone interviewers ring people chosen at random from the telephone directory and ask them to respond to questionnaires over the phone. The table below gives the average daily number of "successes" of ten randomly chosen interviewers who were trained using the old training programme and eight randomly chosen interviewers who were trained using a new training programme. At $\alpha = 0.05$, is there evidence that the interviewers trained using the new programme have an increased success rate over those trained using the established programme? Specify any assumptions you are making in relation to the data distribution.

| Average daily number of "successes" | | | | | | | |
|--------------------------------------|----|----|----|------------------------------|----|----|----|
| Established Training Programme | 24 | 22 | 29 | New Training Programme | 27 | 20 | 21 |
| | 26 | 27 | 28 | | 26 | 25 | 25 |
| | 25 | 23 | 27 | | | 19 | 23 |
| | 24 | | | | | | |
| | | | | | | | |

Sample Mean = 25.5
Sample Standard Deviation = 2.273

Sample Mean = 23.25
Sample Std. Deviation = 2.96

(40 marks)

(ii) You know that 80% of the people applying for a certain job have previous experience of this kind of work. You select a random sample of 5 current applicants.

- What is the probability that exactly three have previous experience of this kind of work?
- What is the probability that at least three have no experience of this kind of work?
- Calculate the mean and the variance of this distribution.

(30 marks)

(iii) A pilot sample ($n = 25$) yields a variance of 96. The variance computed from a later more comprehensive sample survey ($n = 121$) is 144. Do these results indicate that the estimate of the pilot-sample variance may have been too low? Use $\alpha = 0.05$.

(30 marks) [Total 100 marks]

Question 6

(i) The following table shows the annual hours missed due to illness for the 24 men and women at the Western Cleaning Company. Can it be concluded on the basis of these data that in this company, on average, the men have higher absence rates than the women? Use the 0.05 level of significance for your test. Indicate why you believe the test you chose to use is the most suitable one for this problem.

| Women | | | Men | | |
|-------|----|----|-----|----|----|
| 38 | 34 | 33 | 31 | 44 | 25 |
| 47 | 58 | 83 | 30 | 70 | 63 |
| 18 | 36 | 41 | 54 | 42 | 36 |
| 48 | | | 22 | 25 | 50 |
| | | | | 49 | 61 |

(60 marks)

(ii) Qualitech has recently installed radio-as-you-work on its shop floor, by connecting into Radio Galway and having it broadcast on its intercom system. The objective is to relax the workers and lead to greater productivity. The production manager is very sceptical about this. She sampled the weekly production output for 6 workers before the music was installed and for the same six workers about two months after the music was installed (so that any "novelty effect" would have worn off.) Her data are given below. At $\alpha = 0.05$, is there evidence that the average production has changed?

| Employee | 1 | 2 | 3 | 4 | 5 | 6 |
|--------------------|-----|-----|-----|-----|-----|-----|
| Week without Music | 219 | 205 | 226 | 198 | 209 | 216 |
| Week with Music | 235 | 186 | 240 | 203 | 221 | 205 |

(40 marks)

[100 marks]