MANAGEMENT STUDIES TRIPOS
DIPLOMA IN MANAGEMENT STUDIES

Wednesday 30 April 2003 9.00 – 12.00

Paper M2

QUANTITATIVE METHODS AND OPERATIONS MANAGEMENT

*Answer **four** questions, **two** from Section **A** and **two** from Section **B**.*

*Answers to sections **A** and **B** must appear in two separate booklets.*

All questions carry the same number of marks.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

SECTION A

1 (a) All students enrolled in a postgraduate diploma in business studies at a technical college have provided, as part of their application for the diploma, their scores on a test, which includes a section of questions on Written Comprehension. The diploma lecturer for the Strategic Analysis course believes that the marks for the course reflect the difficulties that some of her students had in synthesizing the course readings and case studies. She asks the Admissions Office to investigate further. The Admissions Office samples the records of five Strategic Analysis students, and assembles a table of their scores on both Written Comprehension and Strategic Analysis:

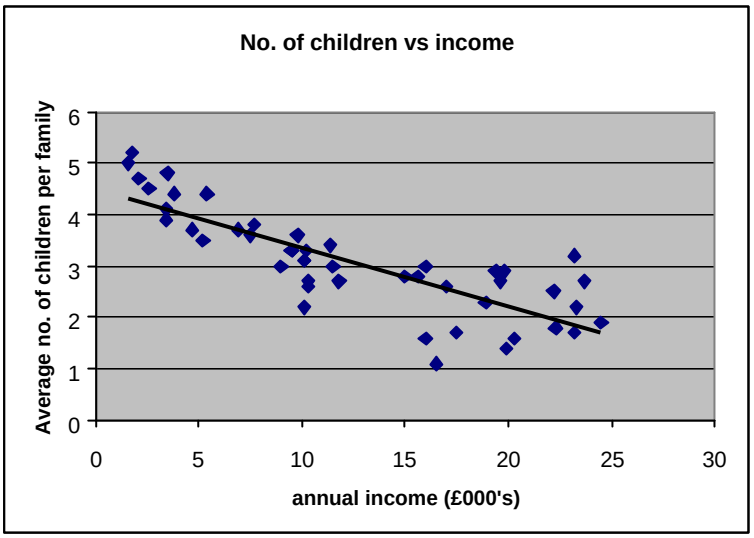
Written Comprehension (out of 100)	Strategic Analysis (out of 100)
71	60
77	69
60	59
72	68
87	70

(i) Do these data support the view that the better a student performs in Written Comprehension, the better he or she will perform in Strategic Marketing? Explain how you performed this analysis, including details of any calculations used.

(ii) Noticing that any student's Written Comprehension score is often 10 marks or more above their Strategic Analysis score, the Admissions Office subtracts 10 marks from each of the former. What effect will this have on the analysis you performed above? Explain.

cont…..

(b) As part of a study of globablisation, a number of regions from ten countries across the world have been surveyed. The results from the study include, for each region, the average family income in thousands of pounds, and the average number of children per family. These data and the line of best fit are



plotted in the graph.

Regression analysis yields the following results:

Regression Statistics	
Multiple R	0.816
R Square	0.665
Adjusted R Square	0.658
Standard Error	0.578
Observations	47

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	4.491	0.173	25.974	0.000	4.142	4.839
X Variable	-0.114	0.012	-9.455	0.000	-0.139	-0.090

(i) For a hypothetical region where the family income is £14,000 on average, give an estimate, C, of the average number of children per family.

(ii) If you collect data from a region where the average family income is around £14,000, with what confidence do you believe the average number of children per family will lie within one unit of C?

(iii) Discuss the application of regression in the above situation by making up to three brief points.

TURN OVER

2 "Trump" is an investment product that you can invest in at any time and that matures, i.e. pays the value of the investment, after one year. A financial analyst's report on this product says it will deliver the following rates of return each year for the next two years:

High (11% per annum) with 60% chance
Low (-5% per annum) with 40% chance

(For example, the chance that the rate of return will be low is 40% for next year and also 40% for the year after that.) By comparison, your bank account will pay 4% per annum for the next two years. You have £50,000 savings to invest. In the following, return is defined as the amount of money you have at the end of the period in question.

(a) To maximise your expected return over one year, is it better to put all your money into the bank or into Trump? What value is your maximum expected return, to the nearest hundred pounds?

Now consider a two-year investment decision where you must decide between two strategies: "Bank", where you deposit your money in the bank for two years, and "Flex", which is to invest in Trump for the first year, then reinvest in Trump if first year returns are high, otherwise deposit all funds in the bank for the second year.

(b) Use a decision tree to optimise the return on £1 by comparing Bank against Flex. Give the expected return to the nearest penny.

(c) If you invest all £50,000 using one of the two strategies Bank or Flex, what is your optimal strategy and its expected return? Give the optimal return to the nearest hundred pounds.

(d) Do you need to alter your optimal two-year strategy if you want to limit potential losses to at most 1% of your initial investment? If not, why not? If so, what is your new strategy and expected return?

3 You work in a large company that manages and maintains fleets of cars for commercial rental. As part of a routine review process, you are called on to analyse the workload of the call centre which deals with customers' telephone inquiries regarding travel information and emergency roadside help.

(a) The length of time company representatives spend answering each telephone inquiry is logged. The data for a number of inquiries is summarised below, where calls under 30 seconds (usually wrong numbers) are omitted:

Length of call (Minutes)	No. of calls
$0.5 \leq$ length of call < 3.5	6
$3.5 \leq$ length of call < 6.5	14
$6.5 \leq$ length of call < 9.5	19
$9.5 \leq$ length of call < 12.5	25
$12.5 \leq$ length of call < 15.5	21
$15.5 \leq$ length of call	17
The average length of the calls lasting 15.5 minutes or more is about 21 minutes.	

(i) Find the mean and standard deviation in minutes, to one decimal place, of the length of calls.

(ii) Find the mode and median bins.

(iii) What is the probability of a random call taking between 9.5 and 12.5 minutes? With what confidence can you say that an average call takes between 9.5 and 12.5 minutes? Express **both answers** as percentages with one decimal place of accuracy.

(b) Your next task is to look at the amount of time taken by "multi-call" customers, who call several times with not more than 3 hours between successive calls. Multi-call data is categorised into double calls, triple calls and quadruple calls, where the last category includes all multi-calls comprising four or more calls. The length of a multi-call is the total time taken for all calls comprising the multi-call (for example, a multi-call consisting of two calls of lengths 17 and 12 minutes is said to be a double call of length 29 minutes). Rough estimates on average lengths of multi-calls are 25 minutes for double calls, 30 for triple calls and 35 for quadruple calls. Out of all multi-calls, the rough probabilities of double, triple and quadruple calls are 0.4, 0.4 and 0.2 respectively. What are the mean and standard deviation of the length of multi-calls? Give your answers in minutes to one decimal place.

4 A travel agency is analysing the air travel costs of its customers. A random sample of customers departing in 2002, whose air tickets cost between £500 and £2,000, appears below:

Size of Order (£)	Number of sales	Number of business class fares
500-750	17	2
750-1000	24	5
1000-1250	14	5
1250-1500	27	7
1500-1750	16	6
1750-2000	12	6

(a) From previous years' sales data, 20% of customers whose air tickets cost between £500 and £2,000 flew business class. Is 2002 significantly different? Explain your reasoning including the calculations that are needed to arrive at your answer.

(b) Suppose that P is the actual percentage of all business class customers whose air tickets cost between £500 and £2,000. How would the travel agency be able to use its sales records to estimate P within the interval [P – 2, P + 2] with 95% confidence? Use the rule of thumb for normal distributions when giving your analysis.

(c) Your boss is familiar with the terminology "95% confidence interval" but doesn't know where it comes from. Your response is to outline the Central Limit Theorem in words rather than mathematics or statistics: in particular, explain what issue(s) the CLT addresses, and why the CLT is important. Give your answer in 80 words or less.

SECTION B

5 The following three questions are based on the reading, 'Controlling Variation in Health Care: A Consultation from Walter Shewhart'.

(a) List the key features of Total Quality Management.

(b) What did Walter Shewhart mean by a 'system of chance causes'? Compare this with Demming's concept of 'common causes'.

(c) What did Shewhart mean by 'assignable causes'?

In the book *The Goal*, it was pointed out that a certain rule must be established with regard to the work at the bottleneck in a manufacturing environment.

(d) What was that rule?

6 You have been called in to be a consultant at the manufacturing division of a firm that operates on a 30-day month and produces special batteries for mobile telephones in production runs of 900 units. The operations department determined this production run size as being optimal, i.e., least cost, based on its best estimates of the costs involved. These costs are as follows:

At the beginning of each production run, there is a set-up cost of £11.00. The unit cost of manufacturing a battery is £12.00. At the conclusion of each production run, the goods must be moved to the warehouse, which is located in an adjacent building. This 'warehouse transfer cost' is assessed at £4.00. Inventory holding cost is estimated to be 25p per unit per month. The annual demand for batteries is 36,000.

(a) What is the length of an order cycle?

(b) What is the length of a production run?

(c) Is the estimated cost of holding inventory unusually high or low compared to what you might otherwise expect? Explain.

(d) Why is the firm holding inventory in this case?

7 You have been hired by Lavender Hill, Ltd., a company that manufactures souvenir Eiffel Towers. Your first assignment is to verify the accuracy of the company's demand forecasts. These had been calculated by your predecessor, Fubsy, who is rumoured to have been sacked for incompetence. Company policy is that each calendar month is divided into 'company weeks' of 7 or 8 days so as to insure that each month is comprised of exactly four weeks. Figures for actual demand in October, November and December of last year, are as follows:

October 2002

Week	1	2	3	4
Demand	445	285	720	1105

November 2002

Week	1	2	3	4
Demand	885	1400	1115	1430

December 2002

Week	1	2	3	4
Demand	1060	1375	940	1560

Your new boss, Mr Pendlebury, has asked you to use simple exponential smoothing, and to initialise by using the mean of the data from all of October and the first half of November. Then, you are to determine the one-period-ahead exponentially smoothed forecasts for the 4th week of November and all four weeks of December. When you start to ask Mr Pendlebury what value of alpha to use, he shoots you an angry look and bellows: 'Whichever value of alpha yields a one-period-ahead forecast in the 3rd week of December of 1249.3 for the 4th week of December. This is the value that has already appeared in Lavender Hill's fourth quarter report. This is what Fusby was not able to accomplish, but I am sure that *you* can achieve this! By the way, I have been asked by some trouble-maker on the Board of Directors to explain why I am not using regression analysis to forecast demand here, and I expect you to help me!'

(a) Explain (in no more than 35 words) why exponential smoothing is indeed preferable as a forecasting method here over regression analysis.

(b) To two decimal places, what value of alpha should be used so that the one-period-ahead forecast for the 4th week of December will be 1249.3?

(c) Lavender Hill owns a piece of software for exponential smoothing, but it is not for *simple* exponential smoothing, but rather exponential smoothing *with trend*. In particular, the software requires that a value be inserted for the trend. What would be the most appropriate value to use here? Explain your answer.

8 You have started up a new business called 'Computer Doctor' that provides on-call written assistance for people with software problems in your town. It works as follows:

People ring the Computer Doctor hotline before 7.30 am, speak to a dispatcher who calms them down and asks them to explain as cogently as possible their software problem and the time by which they need their 'Prescription'. The dispatcher records the problem (and their credit card information), assigns it a 'code' (a, b, c, …), logs the order, estimates the delivery time, and places the information in a file for you to consult. You always start work at 8.00 am sharp. Being quite a software wizard, you are able to solve most problems and write out a 'Prescription' for the customer, which consists of a step-by-step set of instructions on how to address their problem. Of course, the length of time you require for preparation, which includes researching, typing, and printing out the 'Prescription', depends on the nature of the customer's problem. A third member of your staff has the role of courier; this person bicycles over to the customer's home and hand-delivers your 'Prescription'. It takes the courier a quarter of an hour to get to any address within the area that Computer Doctor serves.

Upon entering the office this morning, you look over the six customer requests that are logged into the system today:

Request code	Time request logged	Time required for preparation (minutes)	Promised delivery time
a	6.00 am	72	11.30 am
b	6.15 am	186	noon
c	7.10 am	30	1.00 pm
d	7.15 am	132	11.00 am
e	7.20 am	40	10.00 am
f	7.35 am	25	2.00 pm

(a) Find the sequence in which you should complete the customer requests so as to minimise the mean flow time.

(b) Find the sequence that will minimise the number of late prescriptions.

(c) Using this sequence, exactly how many prescriptions are late?

(d) Will the sequence that minimises the number of late prescriptions also minimise the maximum lateness? If yes, explain why this is the case. If no, find a sequence that does minimise the maximum lateness.

(e) In general, is there a scheduling rule that will provide a sequence that minimises the average tardiness? If so, specify its name and describe how the rule operates.

(f) Give three specific reasons why the study of the single machine model for scheduling helps us understand more complex scheduling environments.

END OF PAPER

MANAGEMENT STUDIES CHART MC-2
FORMULAE FOR CORRELATION AND REGRESSION ANALYSIS

Consider data pairs (X_1, Y_1), (X_2, Y_2), …, (X_n, Y_n).
Let m_X and m_Y denote the respective means of the X and Y data.
Let s_X and s_Y denote the respective standard deviations of the X and Y data.

The formula for covariance is given by the sum

$$\mathrm{cov}(\mathrm{X},\mathrm{Y}) = \frac{\sum_{i=1}^{n}(\mathrm{X}_i - m_\mathrm{X})(\mathrm{Y}_i - m_\mathrm{Y})}{n}.$$

The formula for the regression coefficient is

$$\mathrm{correl}(\mathrm{X},\mathrm{Y}) = r = \frac{\mathrm{cov}(\mathrm{X},\mathrm{Y})}{s_\mathrm{X} s_\mathrm{Y}}.$$

The formula for the line of best fit is

$$\mathrm{Y} - m_\mathrm{Y} = \frac{r s_\mathrm{Y}}{s_\mathrm{X}}(\mathrm{X} - m_\mathrm{X}).$$

Management Studies Chart MC-1[1]

Table for P ($z \geq Z$) where $z \sim N(0,1)$

[1] Copied from Quantitative Approaches in Business Studies, 5th edition, C. Morris, Pearson Education Limited 2000