MANAGEMENT STUDIES TRIPOS
DIPLOMA IN MANAGEMENT STUDIES

Wednesday 28 April 2004 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) An international management consulting firm is gathering data for its annual review. One aspect of its performance is its ability to estimate the time required for its consulting projects. The table below shows the time overruns of a sample of last year's projects, from its London office, in terms of the "extra-time factor" or ETF, that is, the ratio of total time required to the amount that was estimated in advance. (For example, a project that was costed on the basis of 5 person-days but that actually took 6 person-days to complete would have an extra-time factor of 1.2.)

ETF ranges	Number of Projects
1.0 to 1.1	20
1.1 to 1.2	15
1.2 to 1.3	17
1.3 to 1.4	11
1.4 to 1.5	7
1.5 to 1.6	3
1.6 to 1.7	2
over 1.7	2

(i) Find the average ETF, and the ETF range containing the median ETF.

(ii) Give a conservative estimate for the average ETF, i.e. a value that would be larger than the average with 95% confidence.

In your calculations, use the mid-point of extra-time factor ranges (e.g. use 1.05 for the range 1.0 to 1.1), and use 2 as the average for the "over 1.7" range.

(b) Discuss the validity of the headline for the following news report:

Prime Minister's approval rating slips.

Prime Minister Shrub, hit by a nightclub scandal involving his daughters and continuing bad publicity over allegations of favouritism in handing out government contracts, has slipped in the polls. Last Monday's poll of 905 registered voters showed Shrub's approval rating as 52 percent. A similar poll one month ago had Shrub's approval rating as 55 percent.

2 (a) As the manager of a car rental agency, you are considering the question of how often to replace your vehicles. Your most popular budget model is a two door, four-seater car, referred to as a "sedan", which costs around £12,000 and is replaced after 3 years. The return on each sedan, which takes into account lower rental charges and increasing maintenance costs as the car ages, is given by the revenues it earns: £9,000 in year 1, £5,000 in year 2, and £3,500 in year 3. A 3-year-old sedan can be sold for £3,000. You have recently been approached by a car manufacturer who offers a new sedan in exchange for a used sedan that is not more than a year old, plus £6,000.

Answer the following:

Compare a 3-year replacement strategy against three successive 1-year replacements using the discounted trade-in each time. In the latter case, assume that the cost of the car at the start of year 1 is only £6,000 (i.e. you are trading in a sedan that was bought at the start of the previous year). Use a discount rate of 10% per annum and, for simplicity, assume that car rental revenues for any year are paid at the end of that year.

(b) Mary is the owner-manager of a retail store specialising in ladies' eveningwear. Due to competition from larger stores and rising rental costs, Mary has been forced to lay off one of her sales people, Jo. Unfortunately, Jo is threatening legal action against Mary, claiming that her (Jo's) dismissal was the ultimate act against her by Mary in a long series of bullying incidents. Mary has taken legal advice, costing £500, and her two options now are summarised as follows. Option 1. Do nothing right now; just wait to see if Jo submits the bullying claim to the Employment Tribunal. Option 2. Offer a settlement payment of, say, £3,000 pounds to Jo on the condition that Jo would take no further action. If Jo accepted such an offer, Mary's costs would include her current legal fees plus the settlement payment. If Jo rejected such an offer, however, then she would surely submit the claim of bullying to the Employment Tribunal.

According to Mary's legal advice, should the Employment Tribunal be called on to settle the dispute then it would be 80% likely to rule in Mary's favour, resulting in no further costs (her additional legal costs would be paid by Jo). Should the Employment Tribunal rule against Mary, however, then Mary would have to pay around £12,000 compensation plus further legal costs of around £2,000 (hers and Jo's) which, in total, would be close to the cost to keeping Jo on staff for a year. Mary estimates the chance of Jo going to the Employment Tribunal as 50% in option 1 and 25% in Option 2.

(i) Give a decision tree to help Mary decide which option to choose.

(ii) Suppose Mary chooses Option 2. Give the standard deviation of outcomes that she faces. Is this a good measure of risk for Mary's situation? Briefly explain.

3 (a) BritBeef is a meat processing company whose products include beef patties for hamburgers. Its main sources of beef are from Cumbria and southwest Scotland. In the next two months BritBeef has the opportunity to stock fresh beef as described in the table.

	Cumbria beef	Scottish beef	Other UK beef
Cost (£ per kilogram)	1.15	1.25	1.05
Availability (kg), up to:	120,000	80,000	60,000

BritBeef markets its patties as a high quality UK product comprising not less than 30% of Scottish beef and not less than 50% Cumbria beef. Processing costs around £0.3/kg and the company sells its patties at £1.50/kg. Over the next two months, BritBeef can process up to 250,000kg of beef, and expects to sell all the patties that it produces.

(i) Give a linear programming model for optimising BrifBeef's profit on patties.

(ii) In fact, although 120,000kg of Cumbria beef is available, only the first 100,000kg is available at the stated price; each remaining kilogram up to 20,000kg will cost 10% more. Adapt your LP model from part (i) to take account of this higher cost.

(iii) Next, suppose that instead of paying 10% more for Cumbria beef in excess of 100,000kg, Britbeef pays 10% less. Comment, in 80 words or less, about whether an adaptation of your part (i) model, similar to part (ii), would make sense in this case.

(Note that you are <u>not</u> expected to solve the LPs in part (i) or part (ii).)

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(b) The Widget Company is planning next week's production of widgets and gadgets. The limiting factor in production each week is the availability of labour, which is required for assembly, painting (gadgets only) and packing. The availability of labour next week is as follows:

	Hours used per unit produced		Hours available
	widgets	gadgets	
Assembly	0.5	0.2	120
Painting	0.0	1.0	40
Packing	0.3	0.15	100
Unit Profit	£100	£50	

After solving a linear programming model to optimise profit, the following sensitivity information is produced:

Adjustable Cells						
Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B7	widgets	224	0	100	25	100
C7	gadgets	40	0	50	1E+30	10
Constraints						
Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
D10	assembly Total time	120	200	120	44.666667	112
D11	painting Total time	40	10	40	560	40
D12	packing Total time	73.2	0	100	1E+30	26.8

(i) What is the definition of a shadow price in general linear programming?

(ii) Now use the example of the Widget Company, via the sensitivity table, to explain what a shadow price is, how it might be useful in management, and what limitations there are in applying it.

4 (a) EdCo sells educational equipment directly to schools, and relies on personal visits by its sales force of over 50 sales representatives to initiate most sales. The sales manager of EdCo has collected data on the sales performance of a sample of sales representatives over a three-month period. You are a business consultant who has been asked to analyse the data, which shows the value of sales achieved, in thousands of pounds, versus number of schools visited:

Number of. Schools	Sales
63	33
39	15
55	26
57	22
50	25
37	5
55	25
57	27

(i) Find the equation of the line of best fit in the form $Y = a + bX$. What is the level of sales, to the nearest thousand pounds, to be expected from a sales person who visits 55 schools? What statistical support is there for using regression here?

(ii) Is the predictive ability of regression equally useful for both the sales manager and the individual sales representative who wants to know the level of sales he or she will achieve in the next three months? Briefly explain.

(iii) After consulting with the sales manager, you agree that the following additional factors may also have an impact on a sales representative's performance: sizes of schools visited, prior experience of sales representative, and the level of competition for sales in the regions visited by the sales representative. Assuming data are available for these variables, make three brief points to explain the process of including these or other new variables in the regression analysis; write your points in order of their importance.

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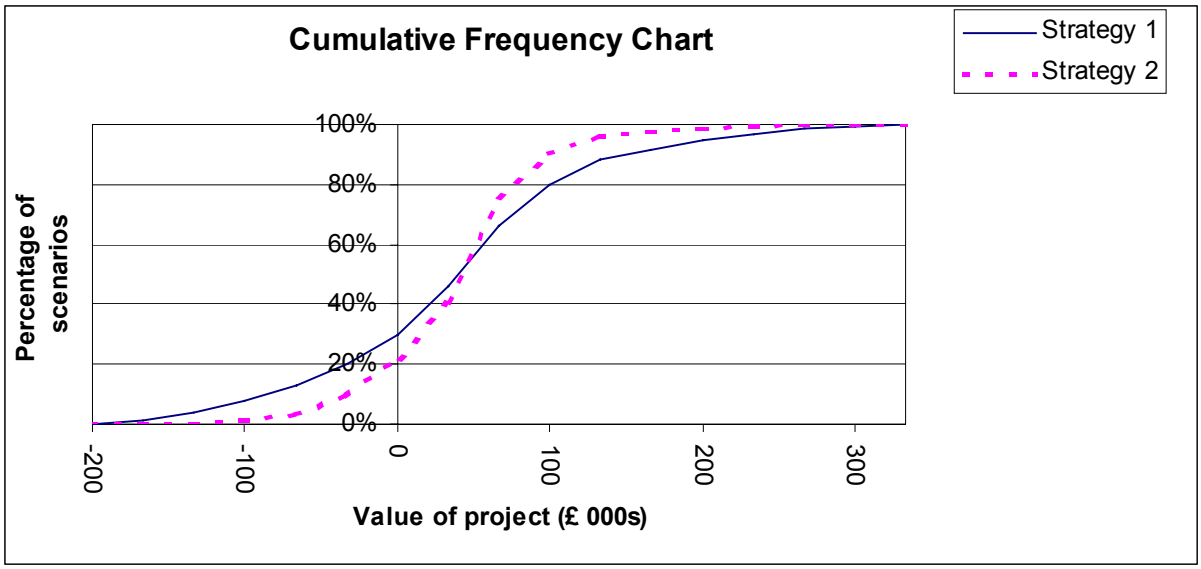
(b) Monte Carlo simulation is used to generate the following cumulative distribution charts for the valuation of a project under two different management strategies:



(i) Roughly estimate a percentage frequency table for each strategy using ranges of size £100,000. Start with the range minus £200,000 to minus £100,000.

(ii) Roughly estimate the expected value of the project under each strategy.

(iii) Briefly compare the two management strategies by making three comparisons of their properties.

SECTION B

5 (a) Concisely explain how the Toyota Production System (TPS) aims to achieve cost reduction.

(b) Concisely explain the connection between JIT production and *jidoka*.

(c) In the Toyota Motor Manufacturing (TMM) case, TMM's Quality Control (QC) Department served a number of functions, including: setting quality standards, following through on the customer's experience with shipped vehicles, assisting assembly group leaders to solve assembly quality problems, and working out component quality problems with suppliers. However, QC served two other unique functions as well. What were these two additional functions?

(d) In the TMM case, there were ***two*** problems associated with the seat-related defects, the first being the seat-related defects themselves. What was the second problem?

6 A cement firm has a fixed cost of setting up production of £1,500 and a variable cost of production of £3.50 per kg. The company uses an interest rate of 22 percent to account for the cost of capital, and the annual cost of storage of cement amounts to 12 percent of the cement's value. The firm works on a 250-day year. The firm can manufacture at a rate of 10,000 kgs per day, and faces an average daily demand of 2,400 kgs.

(a) What is the optimal size production quantity for the firm?
(b) What is the maximum level of on-hand inventory?
(c) What is the annual average cost of holding plus set-up?
(d) What percentage of each cycle consists of the production portion of the cycle?
(e) If the variable cost of production were to change to £7.50 per kg, and the firm were to adjust its production accordingly so as to produce optimally, what percentage of each cycle would then consist of the production portion of the cycle?

7 (a) In the book *The Goal,* Jonah and Alex agreed on what the goal of a manufacturing organisation should be. State this goal in ***two*** different ways.

(b) In *The Goal*, Jonah developed a set of three measurements, which relate to the goal of a manufacturing organisation and also permit one to develop operational rules for running a plant. State these three measurements and explain how they relate to the goal. Make sure you include the definitions Jonah provided.

(c) What reason did Jonah give for not including, amongst his measurements, *labour invested in inventory*?

8 A manufacturer has 60 hours to complete the processing of 10 jobs. Each job requires the same machine for the first operation, which consists of raw processing. The technology is such that 2 jobs cannot be processed together. The second operation, finishing, takes longer, for which as many additional workers as required can be brought in, with the proviso that only 1 worker can work a single job at a time, although, if necessary, jobs can be subcontracted.

(a) Based on the data below, what method or algorithm would be appropriate to apply to this problem?

(b) Assuming you wish to subcontract as few jobs as possible, which jobs should be subcontracted if the 60-hour deadline is to be met?

(c) Provide the optimal schedule.

Time (hours)		
Job	Raw	Finishing
A	7	6
B	7	12
C	12	0
D	10	18
E	4	9
F	14	25
G	10	14
H	11	7
I	5	13
J	4	10

END OF THE PAPER