MANAGEMENT STUDIES TRIPOS
DIPLOMA IN MANAGEMENT STUDIES
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Wednesday 4 May 2005   9.00 – 12.00
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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 **eight** questions carry the same number of marks.*

NB   THE FINAL TWO PAGES OF THIS EXAMINATION PAPER CONSIST OF TWO CHARTS

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   Parts (a) and (b) refer to different situations.

(a)   A financial planner wants to design a portfolio of investments for an investment company. The company has £500,000 to invest and the planner has identified four investment options for the money as shown in the table below. The goal is to maximize expected return earned over the next year. In addition, the company has specified that no more than 30% of the money should be held in any one investment, at least one half should be invested in long-term bonds which mature in six or more years, and no more than 40% of the money should be invested in B or C since they are riskier investments.

Investment Options	Return	Years to Maturity	Rating
A	6.5%	6	1-Excellent
B	8.5%	5	3-Good
C	9.0%	8	4-Fair
D	7.5%	4	2-Very Good

(i)   Help the financial planner to formulate an optimisation model for this investment problem. You are <u>not</u> required to solve your optimisation model.

(ii)   How would your model, of part (i), change under the additional condition that the minimum amount for option A must be over £50,000 if there is any investment in option A?

(b)   Cambridge Furniture produces beds and desks for Cambridge college students. The production process requires carpentry and varnishing. Each bed requires 6 hours of carpentry and 4 hour of varnishing. Each desk requires 4 hours of carpentry and 8 hours of varnishing. There are 360 hours of carpentry time and 400 hours of varnishing time available. Beds generate £30 of profit and desks generate £40 of profit. Demand for desks is limited, so at most 80 will be produced.

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The linear programming model has been formulated as shown below, followed by a sensitivity results table.

Let X_1 = Number of Beds to produce
       X_2 = Number of Desks to produce

The linear programming model for the problem is

$$\text{MAX:} \quad 30 X_1 + 40 X_2$$

Subject to: $6 X_1 + 4 X_2 \leq 360$ (carpentry)
                $4 X_1 + 8 X_2 \leq 400$ (varnishing)
                $X_2 \leq 80$ (demand for X_2)
                $X_1, X_2 \geq 0$

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B4	Number to make: Beds	40	0	30	30	10
C4	Number to make: Desks	30	0	40	20	20

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
D8	Carpentry Used	360	2.5	360	240	160
D9	Varnishing Used	400	3.75	400	266.7	160
D10	Desk demand Used	30	0	80	1E+30	50

(i)   Suppose the company can purchase more varnishing time at £3.00 per hour. Should more varnishing time be purchased and if so, how much?

(ii)   Can you find an optimal production plan for Cambridge Furniture if the profit generated per desk drops to £35? Explain. If yes, what is the optimal value of the objective function?

2   Parts (a) and (b) refer to different situations.

(a)   Office Master is a large international property trust, whose prime business is to own and manage buildings in large financial capitals such as London. With a portfolio of nearly 500 properties throughout the world, Office Master is considering buying one of three different buildings in the UK: An apartment building, an office building, and a warehouse. Office Master estimates that the payoffs from owning the apartment building, the office building, and the warehouse are £50,000, £100,000, and £30,000, respectively, if the economic condition is good, and £30,000, £-- 40,000, and £10,000, respectively, if the economic condition is not good (so in one case the payoff is negative). Market analysis shows that there is a 60% chance that the economic condition will be good in the future and a 40% chance that the economic condition will be not good.

(i)   Construct a decision tree to help Office Master decide which building to purchase.

(ii)   Define the expected value of perfect information and calculate this value for Office Master.

(b)   Jenny needs to open a bank account in September 2005 for her son Rick who is going to undertake his university education for four years starting from September 2006. At the beginning of each academic calendar year, that is, in September of 2006, 2007, 2008 and 2009, Jenny will withdraw £2,000 from her bank account and give it to Rick. She also wants to have £3,000 for Rick at the end of his university time, in September 2010, so that he could enjoy an overseas holiday. Assume the annual interest rate is 5%. What is the amount of money that Jenny needs to invest in her bank account?

3   Parts (a) and (b) refer to different situations.

(a)   The National Centre for Health Statistics publishes data on heights and weights. A random sample of 10 males aged 18 to 24 years, whose heights range between 66 and 75 inches, has been used to develop the following Excel regression spreadsheet of the result.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.915224
R Square	0.837635
Adjusted R Square	0.817339
Standard Error	9.131408
Observations	10

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-358.269	80.50711	-4.45016	0.002139	-543.919	-172.619
Height (inches)	7.426282	1.155967	6.424303	0.000204	4.760616	10.09195

(i)   What is the estimated regression model for this problem? Explain what all the variables and constants mean, if appropriate.

(ii)   Use the regression equation to predict the weight of an 18 to 24 year-old male who is 67 inches tall. Give a rough 95% confidence interval for the predicted weight. Interpret your result intuitively.

(iii) Use the above regression equation to predict the weight of an 18 to 24 year-old male who is 60 inches tall. Explain your answer.

(iv) Provide a 95% confidence interval and a rough 99% confidence interval on the slope of the regression equation. Interpret the meaning of one of them.

(v)   Discuss the significance of your regression model.

(b)   The DGPlus Telephone Company recently performed a study in which 6 households were surveyed to determine the long distance call charges in a year, and the number of people living at the residence. The sample data are listed below.

People	4	2	1	3	5	2
Charges	£36	£24	£20	£30	£46	£22

(i)   Calculate the correlation coefficient between the number of people living at the residence and their yearly long distance call charges. Is it true that as the number of people in a household increases, the yearly long distance charges also increase? Explain your answer.

(ii)   Compute the regression equation based on these sample data and provide an estimate of the average yearly charge for long distance calls for those households that have 4 members.

TURN OVER

4   Parts (a) and (b) refer to different situations.

(a)   Grace Brothers Fashions relies on its sales force of 220 to do an initial screening of all new fashion lines. The company is presently bringing out a new line of winter clothes and has invited 40 salespeople to its London home office. An issue of concern to Grace Brothers is the volume of orders generated by each salesperson. Last year the overall company average was £417,330 with a standard deviation of £45,285.

> (i)   Discuss the shape of the distribution of all possible sample means of sales with sample size 40? Quantify your answer.
>
> (ii)   Determine the probability that the sample mean of sales with sample size 40 will have a sales average greater than £430,000.
>
> (iii)   Determine the probability that the sample mean of sales with sample size 40 will have a sales average less than £400,000.

(b)   A local Cambridge radio station is interested in estimating the percentage, P, of a target market that has favourable impressions of its breakfast show. A pilot sample of 40 people was selected, and 18 of them have a favourable impression of the breakfast show.

> (i)   The station manager thinks that the average percentage with a favourable impression was 39.5% in the past. Do you think the radio station has improved its breakfast show performance?
>
> (ii)   The marketing department wants to know the range [P−3, P+3], where P is described above, with 95% confidence. Estimate the number of people that must be surveyed to achieve this.
>
> (iii)   Explain in non-technical language the general effect of the sample size on the confidence interval. Use 30 words or less.

SECTION B

5   The following are five questions on the topic of inventory.

(a) What does Professor Thomas Sowell say inventory is? Explain what he means. (Answer in 50 words or less.)

(b) One obvious advantage of having low inventories is that inventory-holding costs, including both the physical costs of holding inventory and the opportunity cost of capital, will tend to be low. Describe one other important advantage of having low inventories. (Answer in 50 words or less.)

(c) How do the Economic Time Cycle and Economic Batch Size heuristics differ conceptually?

(d) What are the seven basic assumptions associated with the Economic Order Quantity? (*Hint*: Two refer to the nature of demand, two refer to how the item is obtained, and three refer to the costs involved.)

(e) Cambridge Parts, Ltd., a parts supplier company launched in 1990, has seen its sales increase by a factor of 10 over the last 5 years. On reviewing inventories, the president finds that in fact inventories have also increased by a factor of 10 over that period. The president views this as a signal that the company has been managing its inventories well. Do you agree? Support your answer.

6   The following case is an excerpt from the article 'Amazon Ships to a Sorting Machine's Beat' by Saul Hansell, from the *New York Times*, 24 January 2002, about the new Crisplant sorting machine in Amazon.com's warehouse in Fernley, Nevada, U.S.A.

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Many of [Senior Vice-President for Operations Jeff] Wilke's efforts reflect the highly quantitative bent expected of an M.I.T.-trained engineer who ran chemical plants for Allied Signal before joining Amazon in 1999. But when he talks about the biggest change here in Fernley, he uses the language of music, not manufacturing.

'We needed to build cadence,' Mr Wilke said, 'to operate to the drumbeat of the constraint.'

The drumbeating constraint is the $25 million Crisplant sorting machine at the centre of Amazon's automated approach. Working with batches of 500 to 2,000 orders, the employees with hand-held terminals feed items onto a network of conveyor belts into the sorting machine. The machine reads the bar code on each item and routes it into one of 2,100 chutes, each chute representing an order for a single customer. When all the items in an order are in the chute, a light flashes, and a worker rushes to put them in a box. They are then sent on other conveyers to machines that print packing slips, seal the boxes and send them off to shippers' trucks...

[In] the last two years, Mr Wilke says, he has come to believe that the sorting machines were a good choice. He has also concluded, though, that because they are so expensive and so central to the business, all other parts of the warehouse need to operate with the goal of avoiding backlogs and delays that would prevent the Crisplant machine from running at peak efficiency. So Mr Wilke created a new job — 'flowmeister'— making one person the orchestra conductor of the warehouse, to keep each section of the operation in rhythm with the sorting machine. In Fernley this day, the flowmeister was Andy Warren, a former logistics consultant who took a career detour as a lawyer. His podium was a metal table topped with seven computer screens that monitor all the key processes of the warehouse.

As Mr Warren conducted, a graph showed that the people taking items from the chutes and putting them in boxes were not keeping tempo with the ones putting items into the sorting machine. So he had a worker move from the 'induction' area to work the chutes, heading off a backlog. Mr Wilke's 'cadence' talk was hardly music to the ears of the people who worked in the warehouses, because he was essentially insisting they could handle far more volume with no new equipment.

'I felt like Scotty in "Star Trek" saying, "I can't push her any further, captain," ' said Greg Bennett, the manager of the Fernley warehouse. Yet by keeping the Crisplant operating at full speed for two 10-hour shifts a day, the warehouse was able to pack more than 200,000 items on peak days in December, 30 percent more than the year before.

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The following questions refer to the above case and to the book *The Goal*.

(a) Is the Crisplant sorting machine a bottleneck at Amazon's Nevada warehouse? Justify your answer. (Answer in 50 words or less.)

(b) Andy Warren is one of the 'flowmeisters' for Amazon, whose job it is 'to keep each section in rhythm with the sorting machine.' If Andy instead worked for Alex Rogo in an equivalent position in UniCo's Bearington plant, what would his primary job duties be? Who performs these duties in Unico's Bearington plant now? Be specific. (Answer in 50 words or less.)

(c) What, if anything, is the connection between the musical term 'tempo' (paragraph 5) used at Amazon, and Sharon's [Alex's daughter] suggestion in *The Goal* that Herbie beat a drum? (Answer in 75 words or less.)

7 The following are four questions on the topic of the Toyota Production System (TPS).

(a) A manufacturing firm in adopting the Toyota Production System has fitted its machines with lights that alert workers of defective items so as to prevent the workers from passing the defectives on to the next station. What is the one word term that describes the underlying TPS principle at work here?

(b) Explain (in 30 words or less) the concept of *heijunka*.

(c) A supplier of Toyota is planning to implement *heijunka*. Toyota has recommended that the supplier cut the batch sizes from the current level of 80 down to 20. In order to achieve this, how much should the supplier reduce set-up costs?

(d) The line has not stopped at all for the last two shifts at Toyota Motor Manufacturing in Georgetown, Kentucky. There are two main reasons why this would be cause for concern for the production manager. Give *both* reasons.

TURN OVER

8   You are the operations consultant at a firm. Accounts Receivable (AR) receives an average of 1,000 payments per week. There is an average of 500 cheques waiting to be deposited.

(a) What is the average time spent by each cheque waiting to be deposited?

The cheques coming in are classed as being either small or large. Small cheques have an average value of £500 and large cheques have an average value of £5,000. Of the cheques coming in, 20% are large with the rest being small. Currently no distinction is made with regard to the processing of the large and small cheques. As a result, 20% of the cheques waiting to be processed are large. As operations consultant, you have been asked whether it is worthwhile to reallocate resources (at no additional cost to the company) so that large cheques wait an average of 0.3 weeks, while small cheques wait an average of 0.8 weeks, before being processed.

(b) Is it worthwhile to reallocate resources as described above? (In order to receive credit, you must justify your answer. Answer in 25 words or less.)

(c) By what percentage would the new policy for handling cheques reduce (or increase) holding cost?

END OF PAPER