

Institute of Actuaries of India

Subject CP2B – Actuarial Modelling (Paper B)

November 2020 Examination

INDICATIVE SOLUTION

Introduction

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable.

Summary – Profit Testing

Overview

The purpose of this project is to be able to calculate the profit of the five hospitals owned by the Health Service company in the city of Corland and check the probability of achieving the Profit Target set by the company under multiple scenarios.

Data

Data has been provided for the no. of kits that a hospital can procure and hence the maximum capacity of a hospital. There is a total expected number of patients in the city in normal and outbreak situation.

The charges per patient have also been provided under normal and outbreak situation-

Income received per patient (\$)	50
Income received per patient at outbreak (\$)	40
Number of patients per day	800
Number of patients per day at outbreak	1,300
Increased capacity for hospitals I&II	1.2

Hospital	I	II	III	IV	V (only if excess patients)
Cost per patient (\$)	22	12	35	30	30
Max number of available kits per day- Base	50	500	200	700	NA
Max number of available kits per day- Higher Capacity	60	600	200	700	NA

Assumptions-

The following assumptions have been made in order to calculate the Profit-

- Same amount is charged to each patient
- The total number of patients each day stay constant
- There are no other hospitals in the city where patients can get tested
- Hospital V can always handle as many cases as referred
- Other expenses are ignored
- Taxes are ignored
- Database of hospital is strong and no patients get missed from records

Calculation Approach

Random numbers between 0 to 1 are generated and the formula (Random number * maximum kits available for each hospital) is used to calculate the no. of kits available in a hospital for that day.

This is done for first 4 hospitals as #5 has no maximum limit and will take all unattended patients.

It is given that the patients are first referred to hospital with a lower cost. The no. of patients per day for each hospital are calculated similarly.

The patients are first allocated to no. I & II. Total of the maximum capacity for these is always less than total patients so all the patients which can be attended in these hospitals as per simulation are first referred here.

Remaining patients are allocated to #IV first as that is lower cost. In case there are still patients left then those are allocated to #III depending on simulated numbers for them.

Any patients left after allocation to all 4 are then referred to V.

It is checked that no hospital is allocated more patients than the maximum capacity and total number of patients are 800.

Income from 800 patients is calculated to be $800 \times \$50 = \$40,000$

Cost for each hospital is calculated by no. of patients referred there (calculated as above) multiplied by cost per patient for that hospital. This cost is added across all hospitals for each simulation.

Profit for each simulation is calculated and compared with the Profit Target for company. Similar calculation is repeated with higher capacity for hospital I&II.

For the above calculation, the additional capacity of 20% is multiplied to maximum available kits for Hospital I&II. This is Scenario 1(a).

Calculation above is repeated with higher capacity to calculate the profit range and probability to beat profit target under this higher capacity. This is scenario 1(b).

In outbreak situation, the above two calculations are repeated with higher no. of patients and lower charges per patient as per regulated charge. These are Scenario 2(a) and 2(b) respectively.

Results –

The profits under different scenarios look like below-

Scenario 1(a) – Base capacity of hospital / Normal Situation-

Maximum profit	25,222
Minimum profit	15,625
Mean profit	20,122
Profit target	20,000
Number of simulations where profit > target	47
Probability to meet target profit	47%

Scenario 1(b) – Higher capacity of hospital I&II/ Normal Situation-

Maximum profit	27,058
Minimum profit	15,690
Mean profit	21,037
Profit target	20,000
Number of simulations where profit > target	55
Probability to meet target profit	55%

Scenario 2(a) – Base capacity of hospital/ Outbreak Situation-

Maximum profit	21,386
Minimum profit	12,625
Mean profit	16,896
Profit target	20,000
Number of simulations where profit > target	15
Probability to meet target profit	15%

Scenario 2(b) – Higher capacity of Hospital I&II / Outbreak Situation-

Maximum profit	23,748
Minimum profit	12,690
Mean profit	17,782
Profit target	20,000
Number of simulations where profit > target	31
Probability to meet target profit	31%

The charts for the profits under each simulation against profit target are as below-

Chart 1- Profits with Base and higher capacity under normal situation

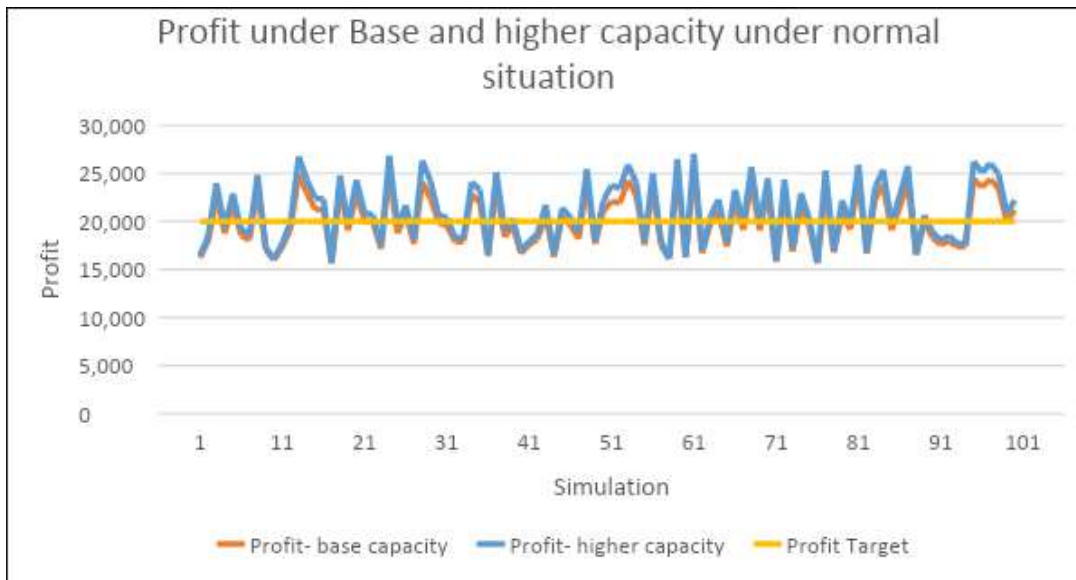
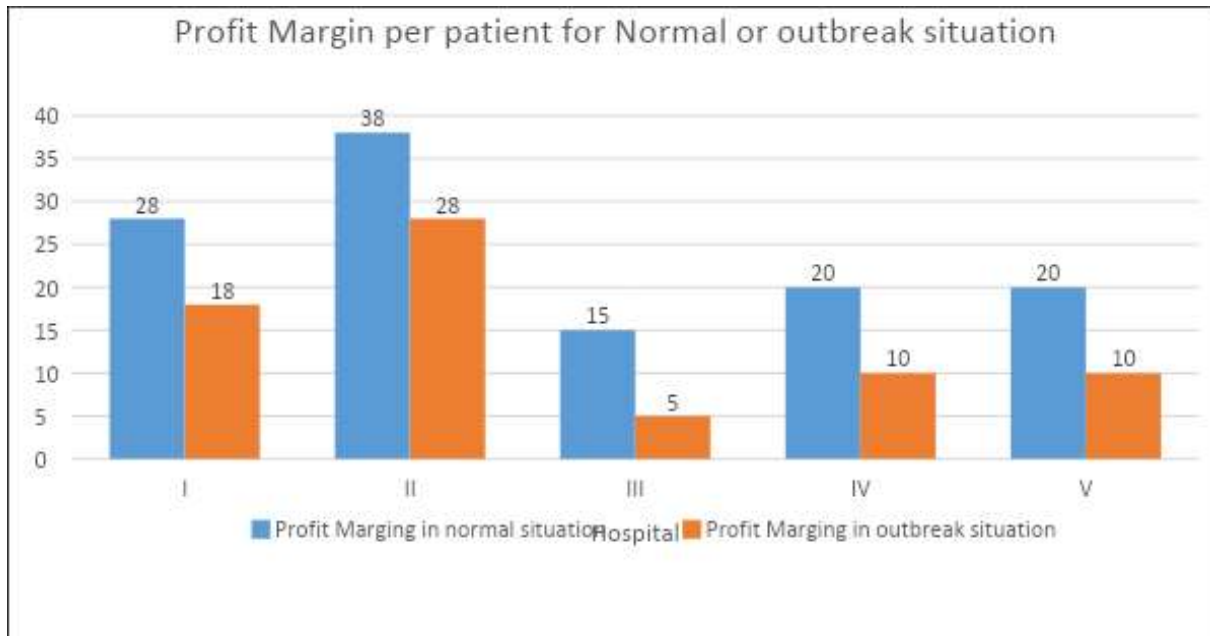


Chart 2- Profit Margin per patient for Normal or outbreak situation-



Conclusions-

- Looking at results for Scenario 1(a), 1(b) and chart 1, we know that the probability of achieving the profit target is higher under higher capacity.
- Also, the minimum and maximum profits are increased in higher capacity of hospital I&II.
- The cost for hospital I&II is less than the cost for V and hence the margins are higher. With same income, the cost is reduced as more patients are tested in lower cost hospitals. This helps in increasing the profits overall
- Looking at results for Scenario 2(a) and 2(b), The profits under outbreak situation have reduced.
- This is because the margins for each hospital have gone down.
- Though the number of patients has increased but the profits have not increased as the capacity for low cost hospitals is same and all additional patients would be referred to hospital V which is a higher cost one with lower margin
- In chart 2, the comparison is done for profit margin for each hospital for each patient. This has gone down due to the restriction on charges for testing.
- The profits in outbreak situations have reduced significantly. The probability of meeting profit target in outbreak situation has reduced to more than half. (15% against 47%)
- From Scenario 1(b) and 2(b), we see that with higher capacity of hospitals I & II, the probability to achieve profit target has doubled.
- This is because the hospital I & II have higher margins than other hospitals.

Next Steps

- Check the data accuracy.
- Check if different amount can be charged per patient in different hospitals getting additional margins for high cost hospitals
- Suggest the measures for reduction in cost for the hospitals to increase margins
- Try with different random numbers to see if the results are stable
- Are the 100 simulations good or more simulations will be needed for accuracy

- This exercise should be repeated for multiple scenarios of patients being tested in these hospitals i.e. not on basis of low cost hospitals first
- In case the additional kits cannot be returned then what will be the repercussions
- Check if the above situation would increase cost if the kits cannot be used next day
- If the excess kits can be used later, does it reduce overall cost for the hospitals
- Check the impact of the taxes
- Repeat the calculations for different amounts charged from patients
- Try another formula to calculate the no. of kits in each hospital in each simulation
- Check if kits in hospital I&II can be increased further to add profits
- Any regulations like home testing can increase the cost for the hospital
- Check if there are new innovative methods being launched for testing which may reduce the patients in hospital
- Repeat the calculations in outbreak situations with higher patients
- Check the calculations for different costs for each hospital
