A LINEAR PROGRAMMING APPROACH TO MAXIMIZE PROFIT AND MINIMIZE WASTAGE IN A HOSPITAL PRODUCTS MANUFACTURING FIRM- GLOBAL SERVICES LTD.

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ABSTRACT

This research paper has taken up a hospital linen manufacturing firm called
Global Services established in Indore, India for collecting primary data and finding an optimal profit for them in order to minimize the wastage at the production level, using linear programming(simplex). The firm specializes in manufacturing hospital linen, i.e. different types of clothing required in a hospital. It aims at maximising the production and hence the profit within the current costs to get maximum profit.
Linear Programming Simplex method is used under this to determine the areas where there is wastage and under production. These areas with scope of progress can then be worked on based on the results we get by solving the problem. Linear programming will provide the ideal combination of production to maximize profit within certain given constraints.

TORA software is used to analyse the data and give appropriate results.

Key words: simplex, LPP, optimality, feasibility, profit, pivot row/column, Tora.

INTRODUCTION

Today's market is highly competitive and for the manufacturing firm to survive and grow it is extremely important to maximize production at lowest cost and thus generate maximum profit. The challenge is to deal with low capacity and low capacity utilization. This can be done by either cost minimization or profit maximization in order to grow and compete with other organizations of the sector. Resources are scarce; hence they need to be used optimally in order to maximize the profit of the firm. Operations research is carried out in order to do so. The technique of linear programming is a promising one with the best results and help in improving performance. Distinct products require different levels of resources at every phase of production and are subject to certain conditions. Linear programming will provide the ideal combination of production to maximize outputs at a given cost or the least possible cost for attaining a certain output.
The research paper is based on primary data collected from a hospital linen manufacturing company called Global Services, established in Indore, India. The firm specializes in manufacturing 3 products, operation theatre (O.T) gowns, doctor scrubs and baby sets. The aim here is to maximize the profit by increasing the level of production at the given cost. Textile manufacturers face a major issue of wastage of raw material.

This increases the costs of manufacturing and adds to the losses. Therefore, an optimum level of production of each of the products is required in the right proportion in order to generate maximum profit.
The optimum solution obtained will suggest a better level of production for each product and help in allocating the right amount of costs for each in order to achieve the target. Linear Programming is done in order to find the optimal solution for the given firm. This is carried out by the Tora software for operations research.

LITERATURE REVIEW

1.Thais R. Salvador, Silvia M. S. Carvalho, Mayk V. Coelho from DFQM, Federal University of São Carlos, Sorocaba, São Paulo, Brazil in the year 2016 have written a research paper on application of simplex method in the radiotherapy treatment. In this research paper is presented an application of the Simplex Method for solving a problem for cancer treatment by radiotherapy. (thais R. salvador, 2016)

2. Marcos dos Santos, Isis Coelho Lima, Carlos Francisco Simões Gomes, Fabrício da Costa Dias, Marcone Freitas dos Reis, Bruna Russo Bahiana; students from brazil had written a research paper on the topic "APPLICATION OF THE BRANCH AND BOUND ALGORITHM IN THE PLANNING AND PRODUCTION CONTROL IN A TEXTILE INDUSTRY". In the research paper they have derived a production mix to maximize revenues from a female underwear factory located in the mountainous region of Rio de Janeiro, from a given amount of available inputs(constraints) using LPP. (Santos, 2016)

3. Gezahegn Tesfaye, Tesfu Berhane, Berihu Zenebe and Senait Asmelash wrote a research paper on the topic "A LINEAR PROGRAMMING METHOD TO ENHANCE RESOURCE UTILIZATION CASE OF ETHIOPIAN APPAREL SECTOR" which was published in International Journal for Quality Research on 09.02.2016. This study identifies the existing resource utilization level and the profit per month of one of the Ethiopian apparel manufacturing companies using a linear programming technique. (Gezahegn Tesfaye, 2016)

4. Dr Ir. Raden Achmad Harianto wrote a research paper which was accepted on 06 May 2018 in the International Journal of Advanced Scientific Research & Development. The topic of the research paper being "OPTIMIZATION OF WOVEN FABRIC PRODUCTION IN TEXTILE INDUSTRY OF PT. ARGO PANTES TANGERANG". PT. ARGO is a manufacturing company which does the job of processing yarn and making woven fabric. The paper solved the equations taking into consideration the constraints and maximized the business profit by using the application of linear programming via Simplex method. (harianto, 2018)

5. Solution of Linear Programming Problem by New Approach- Kirtiwant P. Ghadle, Tanaji S. Pawar and N.W.Khobragade. Department of Mathematics, Dr B. A. M. University, Aurangabad-431004. Department of Mathematics, RTM Nagpur University, Nagpur wrote a research paper on an alternative method for simplex method. It is a powerful method to reduce number of iterations and save valuable time. (Kirtiwant P. Ghadle, 2014)

METHODOLOGY

The Simplex method is an approach to solving linear programming models by hand using slack variables, tableaus, and pivot variables as a means to finding the optimal solution of an optimization problem. In this approach, we obtain the best outcome (maximum profit/ minimum cost) within certain given constraints. The following steps are followed:

- Defining the key variables for each product type (x1, x2, x3)
- Setting objective function (in this case, maximising profit)
- Forming mathematical expressions for the constraints
- Non- negative constraints (value of units cannot be negative)
- Solving the mathematical model using the software

There are multiple computer software that can be used to solve the problem and provide an optimum solution. The one used in this case is Tora. M.S. Excel Solver can also be used for the same. A graphical method is the easiest method to obtain and comprehend the solution. However, in real life scenarios, the number of variables and constraints is too high for a graphical solution. This is why only an algebraic solution is obtained.

Inequality type	**Variable that appears**
≥	- surplus + artificial
=	+ artificial
≤	+ slack

Collection of data

The data is collected from a hospital products manufacturing firm named Global Services Ltd. Established in Indore, India. The data including the cost of raw material (cloth, thread), cost of labor (cutting, stitching) and logistics are taken for 3 products:

1. Operation theatre gowns
2. Doctor's scrub
3. Baby set

The RHS of the subject to constraint equations are the total values/quantity of material available and the labour hours available.
The objective function is the maximizing function with the profit of each type of product times the quantity of that product which should be produced to maximize the profits of the company within the given constraints.

Assumptions:

- The data provided by the company is valid.
- All quantities and labor hours are positive.

ANALYSIS

There are 3 products manufactured at the firm that are: O.T. gowns, doctor scrubs and baby sets
There are various costs involved in the process of manufacturing the above. These include

1. Cost of raw material
   - Cloth

- Thread
- Black grips
- Plastic
- Velcro

2. Cost of labor
   - Cutting
   - Stitching
   - Collar canvas
3. Loading and unloading cost

The aim is to find out the level of production of each of the given products that generates the maximum profit. This should be done keeping in mind the cost constraints. The following table shows the list of constraints and the profit per product. All the costs are taken in Rupees.

PRODUCT TYPE	VARIABLE	RAW MATERIAL COST		LABOUR COST		LOADING/ UNLOADING	PROFIT PER UNIT
		CLOTH	THREAD	CUTTING	STITCHING		
O.T. gowns	X1	2.5	0.25	0.8	1.1	2	123
Doctor scrubs	X2	4	1	1	1	2.9	126.1
Baby sets	X3	1	0.5	1	1	0.5	18.1

Other than this, there are some other costs that are specific to certain products.
O.T. gowns require black grips for hand cuffs which are 50 per unit
Doctor scrubs incur labor cost for collar canvas, which is 30 per unit.
Baby sets require plastic for under sheet at 50 per unit and Velcro which is 0.90 per piece.

There are variables assigned for each product.

- X1- O.T. gowns
- X2- doctor scrubs
- X3- baby sets

These variables are subject to the following constraints

1. Cost of cloth
   $2.5x1 + 4x2 + x3 <= 35000$

2. Cost of thread
   $0.25x1 + x2 + 0.5x3 <= 8500$

3. Cost of cutting
   $0.8x1 + x2 + x3 <= 85000$

4. Cost of stitching
   $1.1x1 + x2 + x3 <= 87000$

5. Cost of loading/unloading
   2x1 + 2.9x2 + 0.5x3 <= 25000

6. Cost of black grips
   50x1<= 200000

7. Cost of labor for collar canvas
   30x2<= 150000

8. Cost of plastic
   50x3<= 25000

9. Cost of Velcro
   0.90x3<=4500

The Tora software was used to find an optimal solution for the given case keeping in mind the constraints. The objective function is Max Z= 123x1 + 126.1x2 + 18.6x3.
After the constraints are identified, the data is entered in the software for the optimum solution.

INPUT GRID - LINEAR PROGRAMMING

	x1	x2	x3	Enter <, >, or =	R.H.S.
Var. Name	O.T. gowns	ctor scrubs	Baby sets		
Maximize	123.00	126.10	18.60		
Constr 1	2.50	4.00	1.00	<=	35000.00
Constr 2	0.25	1.00	0.50	<=	8500.00
Constr 3	0.80	1.00	1.00	<=	85000.00
Constr 4	1.10	1.00	1.00	<=	870000.00
Constr 5	2.00	2.90	0.50	<=	25000.00
Constr 6	50.00	0.00	0.00	<=	200000.00
Constr 7	0.00	30.00	0.00	<=	150000.00
Constr 8	0.00	0.00	50.00	<=	25000.00
Constr 9	0.00	0.00	0.90	<=	4500.00
Lower Bound	0.00	0.00	0.00		
Upper Bound	infinity	infinity	infinity		
Unrestr'd (y/n)?	n	n	n		

This data is then analysed by Tora to give the following results:


LINEAR PROGRAMMING OUTPUT SUMMARY

Title: HOSPITAL LINEN MANUFACTURING
Final Iteration No.: 4
Objective Value (Max) =1131800.00

Write to Printer

Variable	Value	Obj Coeff	Obj Val Contrib
x1: O.T. gowns	4000.00	123.00	492000.00
x2: Doctor scrub	5000.00	126.10	630500.00
x3: Baby sets	500.00	18.60	9300.00

Constraint	RHS	Slack / Surplus
1 (<)	35000.00	4500.00-
2 (<)	8500.00	2250.00-
3 (<)	85000.00	76300.00-
4 (<)	870000.00	868100.00-
5 (<)	25000.00	2250.00-
6 (<)	200000.00	0.00
7 (<)	150000.00	0.00
8 (<)	25000.00	0.00
9 (<)	4500.00	4050.00-

Sensitivity Analysis

Variable	Current Obj Coeff	Min Obj Coeff	Max Obj Coeff	Reduced Cost
x1: O.T. gowns	123.00	0.00	infinity	0.00
x2: Doctor scrub	126.10	0.00	infinity	0.00
x3: Baby sets	18.60	0.00	infinity	0.00

Constraint	Current RHS	Min RHS	Max RHS	Dual Price
1 (<)	35000.00	30500.00	infinity	0.00

The solution states that production of x1, that is, O.T. gowns should be 4000 units; x2, that is, doctor scrubs, should be 5000 units; x3, that is, baby sets, should be 500 units. This would give the company maximum production. The current production level does not give them maximum profit. If the new tora solution is followed, the profit earned is Rs.1131800 (maximum profit).

However, the current production level of the factory is different from the optimum one. The current level of production is as follows.

PRODUCT TYPE	NO. OF UNITS PRODUCED	PROFIT
O.T. gowns	3000	378000
doctor scrubs	4500	567450
baby sets	1000	18600
	Total Profit	*964050*

In the current situation, all the 3 products are manufactured at the factory. This too is profitable. It yields a profit of Rs.964050. This means that there is scope for improvement, which can be achieved by following the Tora data. The profit can be increase by Rs.167750, by following the new production level.

Comparing current and optimum production level and profit:

PRODUCT TYPES	PROFIT PER UNIT	CURRENT PRODUCTI-ON LEVEL	CURRENT PROFIT	OPTIMUM PRODUCTI-ON	OPTIMUM PROFIT
x1	123	3000	369000	4000	492000
x2	126.1	4500	567450	5000	630500
x3	18.6	1000	18600	500	9300

CONCLUSION

The firm initially produces a combination of 3000, 4500 and 1000 units of O.T gown, Dr scrub and baby set respectively to earn a profit of Rs.955050. Using linear programming we found a total profit objective function, subject to constraint functions and non-negative functions and arrived at an optimal solution which

brings in a profit of Rs.1131800, i.e. 18.507% higher than the original profit. For optimal profit, the number of units produced for O.T gown, Dr scrub, baby set should be 4000, 5000 and 500 respectively.
Hence, keeping all the constraints in mind, the firm can improve its performance and alter production to earn 18.507% more profit.

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