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Optimal Production Planning For Patsol's Venture Company Limited Using Integer Programming

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Abstract:

Industrial Production and the flow of resources in an economy are all complexes. Therefore, careful planning and control are required in the production process especially when the real situations being considered are to be integer values. The Various Problems facing industrialists today are as a result of inadequate and improper production planning techniques. This article determines the optimal production schedule of products for the PATSOL'S Furniture Company Limited. A mathematical model was used to represent the real situations based on the data collected. The model was analyzed and solution developed using the Integer Programming Algorithm. The result gives an optimum monthly profit of ₦132, 120.00 with the production of 15 dinning chairs, 485 half upholsteries, 2 full upholsteries and 73 church pews.

Key Words: Industrial Production; Integer Programming, Planning.

1 Introduction:

Industrial Production, the flow of resources in an economy and the existence of military efforts in a war theatre are all complexes of numerous interrelated activities. Differences may exist in their desired goals, processes involved and the magnitude of their efforts. With their similarities in management, a look at the structure, state of the system and objectives to be fulfilled will help in their timing and quantity (proper or schedule) which permits the system to move from a given status to a defined objective. Edwin Man-field (1970) sstated that, a number of military, economic and industrial problems observed can be expressed by mathematical systems of linear inequalities and equations giving rise to the development of Linear Programming. Gomory (1958) devised and worked on a method of solving Integer Programming called GOMORY'S ALGORITHM OR CUTTING PLANE METHOD. This method resembles the simplex method. The optimum is first found without regards to the integers' condition. This places us at a point on the surface of our crystal defined by the restrictions. Our aim is to move the surface of the objective function parallel to itself until we meet our first all integer point inside the crystal at each time to produce a feasible solution and then we add another restriction dependent on the present solution until we finish-up at the required integer point.

1.1 Theoretical Framework And Literature Review:

Taha (1975) and Sharma (2010) defined Integer Linear Programming Problem normally called Integer Problem as a Linear Programming Problem where some of all the decision variables are restricted to the integer value. It can be mixed or pure depending on if the variables are restricted to be integer values. For the purpose of developing Integer Algorithms, a problem is considered Linear if after dropping the integer restrictions on the variables, the equivalent continuous problem is a linear problem. Otherwise, the problem is classified as Non-Linear. The two methods of this programming are classified as SEARCH or CUTTING methods. Kostas (1981) believes that most industrial applications of large scale programming models are oriented towards planning models containing integer valued variables. These include: the equivalent utilization, set-up cost, batch sizes, GO-NO-GO decisions which are concerned with the direct formulation of the problem. Integer Programming will be used to reformulate "ill-constructed" models into the standard format of integer programming. Dakin (1966) modified the branch and bound algorithm for solving integer programming problems which was initially developed by A.H.Land and A.G.Diog in 1972. PATSOL'S Venture Company Limited is a small scale industry of five staff located at No. 12 Ikom-Calabar Highway, Ugep in Cross River State. It is a private organization owned and managed by the Director, Mr. Patrick Okon Ofem. The industry started operations in the year 1995. Their products include: Dinning chairs, Tables of different designs, Beds, Junior upholstery, full upholstery and church pews. The raw materials used are mainly wood and upholstery. Its objective is to maximize profit and help to conserve scarce foreign exchange because it does not need any foreign raw material. The industry uses local materials obtained here in Nigeria which is the modest contribution to the countries industrialization.

1.2 Methodology:

Data used for this research work were collected using the interview method because of its flexibility and the use of questionnaire. The data collected are: The number of processes involved in the production of each type of furniture; the number of hours for the completion of each process; Total hours used for each process per month, the profit made per each type of furniture and for each month.

The data is analyzed using the Gomory's as well as the Branch and Bound's algorithms.

1.3 Data Analysis And Results

Using Table 1 in the Appendix below, we derived the mathematical model as:

$$Maximize\ Z = 200x_1 + 220x_2 + 260x_3 + 300x_4$$

$$subject\ to: 0.7x_1 + 0.5x_2 + 2.0x_4 \leq 400$$

$$0.5x_1 + 0.3x_2 + 0.5x_4 \leq 190$$

$$0.2x_1 + 0.3x_2 + 0.7x_4 \leq 200$$

$$0.5x_1 + 1.0x_2 + 3.0x_3 \leq 500;$$

$$x_1, x_2, x_3, x_4 \leq are\ all\ integers.$$

Step 1:

Some elementary row operations were carried out in Tableau 1 and the final tableau was got.

From Tableau 2, the R.H.S (right hand side) values are for Z, X_4 ,X_1, X_2 and X_3 respectively. Since all the values of x are restricted to integer values, the solutions are not feasible for the given integer problem.

Step 2: Select x_2 with the largest fractional value as a branching variable. (x_2 =485.567)

Step3: Create two linear programming problems by introducing the constraints: x_2 as either $x_2 \leq 485\ or\ x_2 \geq 486$.

The mathematical model then becomes:

$$Maximize\ Z = 200x_1 + 220x_2 + 260x_3 + 300x_4$$

$$subject\ to: 7x_1 + 5x_2 + 0\,x_3 + 20x_4 \leq 4000$$

$$5x_1 + 3x_2 + 0\,x_3 + 5x_4 \leq 1900$$

$$2x_1 + 3x_2 + 0\,x_3 + 7x_4 \leq 2000$$

$$5x_1 + 10x_2 + 30x_3 + 0\,x_4 \leq 5000;$$

$$x_2 \leq 485\ and\ also\ x_2 \geq 486.$$

Solving the above model using the branch and bound method we have tableau 3. The tableau 3 below reveals that the required integer point is $x_1 = 15, x_2 = 485, x_3 = 73$ while the optimal objective function for one month period of production is $z = 132120$ with the production of 15 dinning chairs, 485 half upholstery, 2 full upholstery and 73 church pews. The hourly requirement of the processed items for the optimal production over one month period is:

$$Planning: 0.7x_1 + 0.5x_2 + 2.0x_4 = (0.7 \times 15) + (0.5 \times 485) + (2 \times 73) = 399hrs.$$

$$Sanding: 0.5x_1 + 0.3x_2 + 0.5x_4 = (0.5 \times 15) + (0.3 \times 485) + (0.5 \times 73) = 189.5hrs.$$

$$Varnishing: 0.2x_1 + 0.3x_2 + 0.7x_4 = (0.2 \times 15) + (0.3 \times 485) + (0.7 \times 73) = 199.6hrs.$$

$$Upholstery: 0.5x_1 + 1.0x_2 + \quad 3.0x_3 \quad = (0.5 \times 15) + (1.0 \times 485) + (3 \times 2) = 498.5hrs.$$

1.4 Discussion:

This research result shows that with company production of 15 dinning chairs , 485 junior upholstery, 2 full upholstery and 73 church pews and allocation of 399 hours for planning, 189.5 hours for sanding, 199.6 hours for varnishing and 498.5 hours for upholstery work and finishing will yield a maximum profit of N132,120.00. This shows a profit increase of N52,000.00 against the previous month.

1.5 Conclusion:

This paper presents an integer programming model to support decisions in the aggregate production planning of PATSOL'S VENTURE FURNITURE COMPANY. The model provides useful insights for the decision makers, helping them to better comprehend the variables and important issues that are being considered. It provides an effective analysis of these issues, producing more reliable results and better technical and economical outputs with optimization obtained.

1.6 Recommendation:

It is therefore recommended that, the remaining hours from the total number of hours available per month should be used in the production of half upholstery and church pews since they both contribute immensely to the total monthly profit. Proper pricing of the products should also be made so that their contributions to the objective function will be comparatively high. Marketing strategies should be created for the products with maximum profit as well as increasing the staff strength so as to expand the industry.

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Table 1: Data Analysis and Results.

Furniture Model	Planning (hours)	Sanding (hours)	Varnishing (hours)	Upholstering (hours)	Profit (Z) (Naira)
Dinning Chairs(x_1)	0.7	0.5	0.2	0.5	200
Junior Upholstery (x_2)	0.5	0.3	0.3	1.0	220
Full Upholstery (x_3)	0.0	0.0	0.0	3.0	260
Church Pews (x_4)	2.0	0.5	0.7	0.0	300
Total Time Available per month	400	190	200	500	

Tableau 1

	Z	X_1	X_2	X_3	X_4	S_1	S_2	S_3	S_4	R.H.S.
Z	1	200	220	260	300	0	0	0	0	0
S_1	0	7	5	0	20	1	0	0	0	4000
S_2	0	5	3	0	5	0	1	0	0	1900
S_3	0	2	3	0	7	0	0	1	0	2000
S_4	0	5	10	30	0	0	0	0	1	5000

Tableau 2

	Z	X_1	X_2	X_3	X_4	S_1	S_2	S_3	S_4	R.H.S
Z	1	0	0	0	0	- 920/29	-5450/291	-5950/29	-26/3	-38545000/29
X_4	0	0	0	0	1	9/97	-11/97	-4/97	0	7100/97
X_1	0	1	0	0	0	6/97	25/97	-35/97	0	1500/97
X_2	0	0	1	0	0	-20/97	9/97	65/97	0	47100/97
X_3	0	0	0	1	0	22/291	-43/582	-95/582	1/30	650/291

Tableau 3:

	Z	X_1	X_2	X_3	X_4	S_1	S_2	S_3	S_4	μ_1	μ_2	μ_3	μ_4	R.H.S
Z	1	0	0	0	0	0	0	0	0	-4989/30	-200	-300	-260	132120
X_4	0	0	0	0	1	0	0	0	0	-1/4	-7/20	1	0	73
X_1	0	1	0	0	0	0	0	0	0	0	1	0	0	15
X_2	0	0	1	0	0	0	0	0	0	1	0	0	0	485
X_3	0	0	0	1	0	0	0	0	0	0	0	0	1	2
S_3	0	0	0	0	0	0	0	1	0	-3	-2	-7	0	4
S_2	0	0	0	0	0	0	1	0	0	-3	-5	-5	0	5
S_1	0	0	0	0	0	1	0	0	0	-5	-7	-20	0	10
S_4	0	0	0	0	0	0	0	0	1	-10	-5	0	-30	15

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