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Linear Programming Model in Services Company's Production Cost Management

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Abstract: ***Production companies in Nigeria (Dadaka Flour Mill Nigeria Ltd) are basically concern with the production of quality products needed by its customers subject to the availability of raw material (scarce resources), at the same time not violating the Standard Organization of Nigeria(SON) and National Agency for Food and Drug Administration and control (NAFDAC). The problem then, is on how to utilize the limited resources available, to satisfy the needing demand and at the same time optimize the production cost. In this paper we developed a production cost model for Dadaka Flour Mill Nigeria Ltd as a linear programming problem and solved using POM-QM Optimization software version 3.0; sensitivity analysis was also carried out on the Dadaka Flour Mill Nigeria Ltd production cost model.***

Keywords: Linear Programming, Mazolina, Optimization, Model, Production cost

1. Introduction

Dadaka Flour Mill (DFM**)** Nigeria Ltd produces various types of foods product which includes flour made of maize and wheat and animal feeds. The company's main products are: wheat flour, semolina wheat bran, maize grits, corn flour, and maizolina corn bran. The wheat flour is sold under the brand name 'Dadaka flour' and is enriched with vitamin C and A. semolina is sold under the brand name 'Dadaka semolina'. Wheat bran is produce for livestock feed while maize grits are produce for the brewing process and sold to breweries all over the country. Semolina and maizolina are stable foods. Corn flour is a by-product of the maize mill and is sold for human consumption

Industries all over the world are continuously faced with shortage of production inputs which result in low capacity utilization and consequently low output. An economy can only develop if management decisions at the firm level resulted in boosted output through either cost minimization or output maximization culminating into increased production capacity, hence is the need to plan production (Andrady, 2009). Production planning is the planning of the production process in a company or industry. it includes the resource allocation of material through the activities of employees to improve efficiency and production capacity in order to serve different customer demand(Fargher and Smith, 2006). Though, in the late 1800's manufacturing firms were concerns with maximizing the productivity of the expensive equipment in the factory. Keeping utilization high was an important objective. Foreman rule their shops, coordinating all of the activities need for the limited number of products which they were responsible. They hire operators, purchased materials, manage production and deliver the product. They were expert with superior technical skills, and they planned production (Hermann, 2006).

May practical problems in Operations research can expressed as a linear programming problems. Linear programming (LP) is a technique for optimization of a linear objective function, subject to linear equality or inequality constraints for efficient allocation of limited resources to a desired goal. The "programming" means purposeful planning or scheduling while "optimization" refers to the action of finding the best solution with the given constraints. It is a special case of mathematical modeling (Dantzig, 1963). The general form of linear programming problem is as follows:

$$Optimize \quad Z = Cx \rightarrow \text{Objective function}$$
$$Subject\ to: Ax(\leq = \geq)b \rightarrow \text{Constraint equation}$$
$$b > 0, x \geq 0 \text{ Non} - \text{negativity restrictions}$$

x represent a vector of variables and c and b are vectors of coefficients. A is a matrix of coefficient.

Linear programming can be use in various fields of study. LP is mainly used by mangers to determine the most economical arrangement of finance, to arrange the best time to start and finish a project, and to select projects to minimize the total net present cost of capital (Edward, 2011). Although the modern management issues are ever-changing, most companies would like to maximize profit or Minimize cost (Dadaka Flour Mill Nigeria Ltd) with limited resources. Thus, many issues can be characterized as linear programming problem (Stevenson, 2010). LP has been used in manufacturing industries for years to solve complex problems facing management. Areas that used LP includes: production planning, product mix, assemble-line balancing, blending problems, trim loss, telecommunications and factories. Today LP is a standard tool that has saved thousands or millions of dollars of many production companies, like American Edward laboratories producer of mechanical heart valves, who's annual saving exceed $1,500,000 after using linear programming to select the best vendors that would be supplying its raw materials (Khalid, 2017). It in this light, that we developed a production cost model for Dadaka Flour Mill as a linear programming problem and solved using POM-QM Optimization software version 3.0 to obtain the best production policy with the minimum cost.

For the purpose of this research, the cost of production associated with the production of semovita, semolina and maizolina and quantity of raw materials required as well as available raw materials (limited resources) are considered. A detail of the company's weekly production as at May, 2017 is presented in Table 1.

Table1: Available and Required Quantities of Raw Materials for Weekly Production

		RAW MATERIALS												
Product Type	Tones Produced Per Week	Total Cost (₦)	Carbohydrates (Kg)	Protein (Kg)	Fat (Kg)	Vit. A (Kg)	Vit. B_1 (Kg)	Vit. B_2 (Kg)	Vit. B_3 (Kg)	Vit. B_6 (Kg)	Niacin (Kg)	Iron (Kg)	Thiamine (Kg)	Zinc (Kg)
Semolina	22	4760012	19000	3000	300	0.08	0.2	0.16	0.15	0.18	0	1.43	0	1.68
Semovita	21	4032002	22000	50000	800	0.06	0.24	1.6	1.9	0	1.52	1.34	1.56	0
Maizolina	20	2576012	1700	3500	3900	0.038	0.036	1.16	1.7	0	0.94	1.68	0	0
		Weekly Supply (Kg)	122000	40000	4700	5	5	20	26	3	12	24	10	15

2. Materials and Method

Development of the DFM model

Dadaka Flour Mill Nigeria Ltd wishes to minimize the weekly cost of production. The products consist of semolina, semovita, and mazolina, which are regarded as the decision variables of the model. The weekly cost of production due to semolina, semovita and mazolina are ₦4760012, ₦4032002 and ₦2576012 respectively.

The objective is to minimize the total cost of production and is express as:

$$\text{Minimize Z} = ₦4760012\,x_1 + ₦4032002\,x_2 + ₦2576012\,x_3$$

Subject to the raw material constraint as follows:

To produce 22 tons of semolina per week the company requires 19000 Kg of carbohydrate, 3000Kg of protein, 300Kg of fat, 1.43Kg of Iron, 1.68Kg of Zinc, and 0.08Kg, 0.16Kg 0.2Kg, 0.15Kg, 0.18K of vitamin A, B_1, B_2, B_3 and B_6, 22000 Kg of carbohydrate, 5000Kg of protein, 800Kg of fat, 1.34Kg of Iron, 1.56Kg of thiamine, 1.52Kg of niacin and 0.16Kg, 0.24Kg, 1.6Kg, 1.9K of vitamin A, B_1, B_2, B_3 for 21 tons of semovita per week and 17000 Kg of carbohydrate, 3500Kg of protein, 3900Kg of fat, 1.68Kg of Iron, 0.94Kg of niacin and 0.038Kg, 0.036Kg, 1.16Kg, 1.7K of vitamin A, B_1, B_2, B_3 respectively for 20 tons of mazolina. The supply of which is 122,000 Kg of carbohydrate, 40,000Kg of protein, 4700Kg of fat, 24Kg of Iron, 15Kg of Zinc, 10Kg of thiamine 12Kg of niacin and 5Kg, 5Kg 20Kg, 26Kg, 3K of vitamin A, B_1, B_2, B_3 and B_6 respectively per week.

Thus:
$$19000\,x_1 + 22000\,x_2 + 17000\,x_3 \geq 122000 \quad \rightarrow \text{carbohydrate constraint}$$
$$3000\,x_1 + 5000\,x_2 + 3500\,x_3 \geq 40000 \quad \rightarrow \text{protein constraint}$$
$$300\,x_1 + 800\,x_2 + 3900\,x_3 \geq 4700 \quad \rightarrow \text{fat constraint}$$
$$0.08\,x_1 + 0.16\,x_2 + 0.038\,x_3 \geq 5 \quad \rightarrow \text{vit. A constraint}$$
$$0.2\,x_1 + 0.24\,x_2 + 0.036\,x_3 \geq 5 \quad \rightarrow \text{vit. } B_1 \text{ constraint}$$
$$0.16\,x_1 + 1.6\,x_2 + 1.16\,x_3 \geq 20 \quad \rightarrow \text{vit. } B_2 \text{ constraint}$$
$$0.15\,x_1 + 1.9\,x_2 + 1.7\,x_3 \geq 26 \quad \rightarrow \text{vit. } B_3 \text{ constraint}$$
$$0.18\,x_1 \geq 3 \quad \rightarrow \text{vit. } B_6 \text{ constraint}$$
$$1.52\,x_2 + 0.94\,x_3 \geq 12 \quad \rightarrow \text{niacin constraint}$$
$$1.43\,x_1 + 1.34\,x_2 + 1.68\,x_3 \geq 24 \quad \rightarrow \text{iron constraint}$$
$$1.56\,x_2 \geq 10 \quad \rightarrow \text{thiamine constraint}$$
$$1.68\,x_1 \geq 15 \quad \rightarrow \text{zinc constraint}$$
$$x_1, x_2, x_3 \geq 0 \quad \rightarrow \text{zinc constraint}$$

The complete DFM LP model is

$$\text{Minimize Z} = 4760012\,x_1 + 4032002\,x_2 + 2576012\,x_3$$
$$\text{Subject to: } 19000\,x_1 + 22000\,x_2 + 17000\,x_3 \geq 122000$$
$$3000\,x_1 + 5000\,x_2 + 3500\,x_3 \geq 40000$$
$$300\,x_1 + 800\,x_2 + 3900\,x_3 \geq 4700$$
$$0.08\,x_1 + 0.16\,x_2 + 0.038\,x_3 \geq 5$$

$$0.2\,x_1 + 0.24\,x_2 + 0.036\,x_3 \geq 5$$

$$0.16\,x_1 + 1.6\,x_2 + 1.16\,x_3 \geq 20$$

$$0.15\,x_1 + 1.9\,x_2 + 1.7\,x_3 \geq 26$$

$$1.43\,x_1 + 1.34\,x_2 + 1.68\,x_3 \geq 24$$

$$1.52\,x_2 + 0.94\,x_3 \geq 12$$

$$0.18\,x_1 \geq 3$$

$$1.68\,x_1 \geq 15$$

$$1.56\,x_2 \geq 10$$

$$x_1, x_2, x_3 \geq 0$$

The above linear programming model was solved using POM-QM Optimization software version 3.0

3. Result and Discussion

From the analysis carried out so far one can see that the optimum result derived from the model indicates that two product should be produced, Semolina and Semovita. Their production quantities should be 16.6667 and 22.9167 tons respectively. This will minimized the cost of production to ₦171733600 as shown in Table 2.

Table 2: Result of the Analysis by Pom-Qm Software Version 3.0.

Variables	Status	Value
x_1	Basic	16.6667
x_2	Basic	22.9167
x_3	Non-basic	0
Surplus 1	Basic	69883.3
Surplus 2	Basic	124583.34
Surplus 3	Basic	18633.34
Surplus 4	Non-basic	0
Surplus 5	Basic	3.83333
Surplus 6	Basic	19.3333
Surplus 7	Non-basic	20.0417
Surplus 8	Basic	0
Surplus 9	Basic	22.83333
Surplus 10	Basic	30.5417
Surplus 11	Basic	25.75
Surplus 12	Basic	13
Z	Optimal	171733600

4. Conclusion

Dadaka Flour Mill (DFM**)** Nigeria Ltd produces various types of foods product which includes flour made of maize and wheat and animal feeds. The company's main products are: wheat flour, semolina wheat bran, maize grits, corn flour, and maizolina corn bran. Wheat bran is produce for livestock feed while maize grits are produce for the brewing process and sold to breweries all over the country. Semolina and maizolina are stable foods. Corn flour is a by-product of the maize mill and is sold for human consumption.

To minimize the weekly cost of production, we developed a production cost model for Dadaka Flour Mill Nigeria Ltd as a linear programming problem and solved using POM-QM Optimization software version 3.0. The result of the analysis shows that two product should be produced, Semolina and Semovita. Their production quantities should be 16.6667 and 22.9167 tons respectively. This will minimized the cost of production to ₦171733600 with a weekly saving of ₦100000 per production

5. Recommendation

We therefore, recommended Dadaka Flour Mill (DFM**)** Nigeria Ltd to concentrate in the production of the two products (Semolina and Semovita) in order not to run into high cost. However, further research on cost benefit analysis can be carried out to ascertain the loss in customer goodwill that may result due to non-production of Mazolina before implementing this policy.

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