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Application of Linear Programming for Optimum Production Planning in Maidabino Investment Nigeria Limited, Katsina, Katsina State

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Abstract

The recent high cost of production that rocks all drink producing firms prompted this study to formulate a linear programming (LP) model and arrive at the optimal production plan for Maidabino Investment Nigeria Limited, katsina State, Nigeria. Exploratory research design was adopted for the study and linear programming technique was applied to primary data collected through interview schedule. The production problem of the firm was formulated as a linear programming model. The result showed that Maidabino Investment Nigeria (MIN)limited should produce 750units of 330ml yoghurts and 1,080 units of 750ml of bottle water in order to obtain optimal production cost of one hundred and sixty-five thousand six hundred naira (₦165,600) given the level of available resources and the content of each product per unit of the raw materials. It was also shown that for each extra ₦70 and ₦120 spent on treated water and citric acid for production of 750ml of bottle water and 330ml of yoghurt, overall production cost would fall by ₦1.33 and ₦25 respectively. This is because the resources are binding constraints, fully utilized and have non-zero shadow prices. In addition, any attempt to produce a unit of 1000ml of juice or/and 250ml of ice-cream would raise production cost by ₦260 and ₦250 respectively. For these reasons, it is concluded that production of 330ml yoghurts and 750ml of bottle give MIN limited a great advantages to survive and grow vigorously in the industry. Therefore, the study recommends that management of MIN limited should give more attention to production of 330ml of yoghurt and 750ml of bottle water as the two products give the company optimal production cost.

Keywords:
Optimal production plan, LP, Maidabino Investment Limited

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Background to the Study

Linear programming model is one of the best techniques of managing scarce resources for optimal production globally particularly during high cost of production, economic crisis and recession. Lenka (2013) opined that global economic crisis makes the business environment unfavourable for industries to survive or manage their resources optimally. For instance, in just a few decades we have witnessed the transition from an industrial nation-based resource oriented economy to a global, networked knowledge intensive economy. Manufacturing in Nigeria cannot be left out of this global connectivity in terms of technology, ideals, policies, techniques and procedure for achieving business effectiveness and efficiency.

Profit maximization and cost minimization are the sole aims of all enterprises. There is no doubt that there are limited resources at the disposal of every organization and as a result of this, managers are faced with decision to choose the best means of managing the scarce resources using linear programming in order to maximize profit. Sohi Lord, Bazardch, Khoshsneed, Mahmoodi, Rasbti-Abadi and Mohammad(2013), added that, linear programming plays an important role in improving management decision and has proven to be capable of solving problem such as production planning, allocation of resources, inventory control and advertisement.

Linear programming (LP) can be profitably applied to MAIDABINO investment that produces multiple products in competitive environment just as Winston and Albright, (2000) and Anderson, Sweeney and Willians (2002) observed that LP can be effectively applied to diverse fields including, transportation, telecommunication, energy, blending and production, airline crew scheduling, network flows. Similarly, as a result of the problem of decision making in scarce resources, it is fundamental that application of linear programming model as one of the powerful tools should be applied to MAIDABINO Investment Nigeria Limited, katsina state (MIN Ltd), Nigeria in order to achieve effective decision in its production planning. MAIDABINO Investment Nigeria Limited, Katsina, Katsina State is a sole proprietorship business located in katsina, Katsina State. Basically, the company was established with the main objectives of producing products such as; yoghurt, juice, ice cream and sachet water. To this end, the company has the production capacity of over 5,000 litres of their products per day. The company was duly registered with the National Agency for Food Drugs Administration and Control in order to ensure quality production.

Review of Related Literature

Linear programming is not a new phenomenon in allocation of scarce resources and achieving optimum decision among competing activities. Linear programming (LP)according to Miller (2007) is a generalization of linear algebra use in modeling so many real life problems ranging from scheduling of Airline routes to shipping oil from refineries to cities for the purpose of finding inexpensive diet capable of meeting daily requirement. Miller argues that the reason for the great versatility of linear programming is due to ease at which constraints can be incorporated in to the linear programming model.

Many researchers and authors such as: Akinyele (2007), Imam and Hassan (2009), Ezema and Amaken (2012), Balogun, Jolayemi, Akingbade and Muazu (2012), Waheed, Muhammed, Samule, and Adekinde (2012), Joly (2012), Anieting, Ezugwu and Ologun (2013), Sharmeeni, Jeun and Haeryip (2013), Ihegwara, Esemokumo, Opara and Lebechi (2014) have undergone series of works using linear programming in related studies. Most of these authors recognized and demonstrated that linear programming is an important tool and a relevant technique in making appropriate decision and achieving efficiency in production planning and optimization of available scarce resources in order to attain an optimal profit.

Moreover, the results of the research conducted by Haryadi, Mega and Adi (2015) on production planning using de novo programming at Ceramics company in Indonesia revealed that optimal combination of plates to be produced by the company in the period March 2015 are 68.590 units for the plate size 10 inch, 73.914 units of plate 9 inchand 86.365 units of plate size 8 inch, in order to obtain the maximum profit of IDR4.081.582.000.

Akpan and Iwok (2016) in their study of application of linear programming for optimal use of raw materials in bakery reported that Goretta bakery limited should produce the three sizes of bread (big loaf, giant loaf and small loaf) in order to satisfy her customers and more of small loaf and big loaf in order to attain maximum profit. Therefore, since there is dearth of studies on the company under study the researchers find this study imperative to MAIDABINO investment Nigeria Limited, Katsina for optimal production and profitable performance

Research Methodology

Exploratory research design was adopted for this study. The method is considered appropriate because the study is designed to determine the 330ml of yoghurt, 1000ml of juice, 250ml of ice cream and 750ml of bottle water MAIDABINO Investment Nigeria Limited should manufacture on daily basis in order to minimize production cost given the quantity of available resource consumed by each product and constraint posed in the production process. The study relied on primary data(production cost per each product; limit of available resources i.e powdered milk, sugar syrup, flavour, treated water, culture-DVS, juice concentrate and citric acid; and percentage of resource consumed by each product) obtained mainly through the use of interview scheduled. LP technique was employed to analyze these data and the production problem was formulated as follow:

Objective Function:

Minimize $Z = c_1 x_1 + c_2 x_2 + \ldots\ldots. + c_n x_n$

Subject to:

$a_{11} x_1 + a_{12} x_2 + \ldots\ldots. + a_{1n} x_n \geq r_1$

$a_{21} x_1 + a_{22} x_2 + \ldots\ldots. + a_{2n} x_n \geq r_2$

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$a_{m1} x_1 + a_{m2} x_2 + \ldots\ldots. + a_{mn} x_n \geq r_m$

$x_1, x_2, \ldots\ldots\ldots\ldots\ldots\ldots x_j \geq 0$

$j = 1, 2, 3 \ldots n$
$i = 1, 2, 3 \ldots m$
Where:
Z= objective function that maximized profits
X_j = choice variable (production item) for which the problem is solved
C_j = coefficient measuring the contribution of the j^{th} choice variable to the objective function.
r_i = constraint or restrictions placed upon the problem
a_{ij} = coefficient measuring the effect of the i^{th} constraint on the j^{th} choice variable.

Data Presentation and Analysis

The data for the present work paper was collected from MIN limited. The data consist of production cost per each unit size of 330ml of yoghurt, 1000ml of juice, 250ml of ice cream and 750ml of bottle water and total amount of raw materials (powdered milk, sugar syrup, flavour, treated water, culture-DVS, juice concentrate and citric acid) available for production. The content of each product per unit of the raw material is shown as follows:

a) **330ml of Yoghurt**
0.33kg of powdered milk
0.10kg of sugar syrup
0.20kg of flavour
0.28litres of treated water
0.05kg of culture -DVS
0.04kg of citric acid

b) **1000ml of Juice**
0.15kg of sugar syrup
0.25kg of flavour
0.20litres of treated water
0.07kg of culture-DVS
0.30litres of juice concentrate
0.03kg of citric acid

c) **250ml of Ice Cream**
0.38kg of powdered milk
0.10kg of sugar syrup
0.22kg of flavour
0.30litres of treated water

d) **750ml of bottle water**
0.75litres of treated water

e) **Production cost per unit Product**
330ml of yoghurt = ₦120
1000ml of juice = ₦350

250ml of ice cream = ₦250
750ml of bottle water = ₦70

f) **Quantity available of raw Materials in Stock**
Powdered milk = 600kg
Sugar syrup = 450kg
Flavour = 150kg
Treated water = 810litres
Culture -DVS = 70kg
Juice concentrate = 500litres
Citric acid = 30kg

The above data can be summarized in a tabular form

Table 1: Allocation Table

Products	**330ml Yoghurt**	**1000ml Juice**	**250ml Ice cream**	**750ml Bottle Water**	**Limit of Availability**
Solution Variable	X_1	X_2	X_3	X_4	
Powdered Milk	0.33	0.00	0.38	0.00	600
Sugar syrup	0.10	0.15	0.10	0.00	450
Flavour	0.20	0.25	0.22	0.00	150
Treated Water	0.28	0.20	0.30	0.75	810
Culture-DVS	0.05	0.07	0.00	0.00	70
Juice Concentrate	0.00	0.30	0.00	0.00	500
Citric Acid	0.04	0.03	0.00	0.00	30
Cost	120	350	250	70	

Source: Maidabino Investment Nigeria Limited, Katsina, April2018.

The linear programming model for the above production data is given as:

Minimize $Z = 120x_1 + 350x_2 + 250x_3 + 70x_4$

Subject to:

$0.33x_1 + 0.38x_3 \geq 600$

$0.10x_1 + 0.15x_2 + 0.10x_3 \geq 450$

$0.20x_1 + 0.25x_2 + 0.22x_3 \geq 150$

$0.28x_1 + 0.20x_2 + 0.30x_3 + 0.75x_4 \geq 810$

$0.05x_1 + 0.07x_2 \geq 70$

$0.30x_2 \geq 500$

$0.04x_1 + 0.03x_2 \geq 30$

It is apparent from the second and fifth simplex algorithm tableaus in table 3 and 6 (see appendix) that MIN ltd minimizes production cost to seventy-five thousand six hundred naira (₦75,600) and ninety thousand naira (₦90,000) for 750ml of bottle water and 330ml of yoghurts produced respectively. The overall optimal production cost amounting to one hundred and sixty-five thousand six hundred naira (₦165,600) with production of 1,080 units of 750ml of bottle water and 750units of 330ml yoghurts.

Discussion of Results

Analysis of LP approach on production plan problem in MIN limited revealed duo optimal findings. In the simplex algorithm tableau in table 3, there was an optimal production cost of seventy-five thousand six hundred naira (₦75,600) for production of 1,080 units of 750ml of bottle water as there were no negative values in the objective equation of the objective function. The positive values (94.1), (331.8) and (222) under the 330ml of yoghurt, 1000ml of juice and 250ml of ice-cream imply that that if a unit of the products were produced, then the overall production cost would rise by (₦94.1), (₦331.8), and (₦222) for each product respectively. Similarly, treated water has no unused capacity at optimum and has fully utilized the constraint it represents at ₦1.33. However, for each extra ₦70 spent on treated water the overall production cost would fall by ₦1.33. This is possible because the resource is the only raw material for bottle water production and a binding constraint that is fully utilized with non-zero shadow price.

On the contrary, this study went further to establish optimal production cost among other products of MIN limited with more than one raw material. Simplex tableau in table 6 (see appendix) showed minimum possible production cost of ninety thousand naira (₦90,000) for production of 750 units of 330ml of yoghurt and for each extra ₦120 spent on citric acid for production of 330ml of yoghurt, overall production cost would fall by ₦25.Besides, any attempt to produce a unit of 1000ml of juice or/and 250ml of ice-cream would raise production cost by ₦260 and ₦250 respectively.

Conclusion and Recommendation

This study successfully demonstrates the applicability of the linear programming technique to the production planning problem in MIN limited. The study has given insight into how best production can be effectively planned so that optimal production cost could be realized with available production capacity and resources. The results revealed that using the linear programming model overall production cost could be optimized to one hundred and sixty-five thousand six hundred naira (₦165,600) with production of 1,080 units of 750ml of bottle water and 750units of 330ml yoghurts. Hence, it is concluded that production of 330ml of yoghurt and 750ml of bottle water is essential to MIN limited to always thrive in the market. Therefore, this study recommends that the management of MIN limited should give more attention to production of 330ml of yoghurt and 750ml of bottle water as the two products give the company optimal production cost. They should also ensure that the resources available are utilized optimally in order to minimize production cost to the barest.

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Appendix

Table 2: First Simplex tableau

Products	330ml Yoghurt	1000 ml Juice	250ml Ice cream	750ml Bottle Water	Limit of Availability	Surplus Variables							Solution Qty
Solution Variable	X_1	X_2	X_3	$\mathbf{X_4}$		A_1	A_2	A_3	A4	A_5	A6	A_7	
Powdered Milk	0.33	0.00	0.38	**0.00**	600	1	0	0	0	0	0	0	**0.00**
Sugar syrup	0.10	0.15	0.10	**0.00**	450	0	1	0	0	0	0	0	**0.00**
Flavour	0.20	0.25	0.22	**0.00**	150	0	0	1	0	0	0	0	**0.00**
Treated Water	**0.28**	**0.20**	**0.30**	**0.75**	**810**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1,080**
Culture-DVS	0.05	0.07	0.00	**0.00**	70	0	0	0	0	1	0	0	**0.00**
Juice Concentrate	0.00	0.30	0.00	**0.00**	500	0	0	0	0	0	1	0	**0.00**
Citric Acid	0.04	0.03	0.00	**0.00**	30	0	0	0	0	0	0	1	**0.00**
Cost	120	350	250	**70**		0	0	0	0	0	0	0	**0**

Source: Authors' Computation, May 2018.

Table 3: Second Simplex tableau

Products	330ml Yoghurt	1000ml Juice	250ml Ice cream	750ml Bottle Water	Surplus Variables							Solution Qty
Solution Variable	X_1	X_2	X_3	$\mathbf{X_4}$	A_1	A_2	A_3	A_4	A_5	A_6	A_7	
Powdered Milk	0.33	0.00	0.38	0.00	1	0	0	0	0	0	0	0.00
Sugar syrup	0.10	0.15	0.10	0.00	0	1	0	0	0	0	0	0.00
Flavour	0.20	0.25	0.22	0.00	0	0	1	0	0	0	0	0.00
750ml of bottle water (x_4)	**0.37**	**0.26**	**0.40**	**0.10**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1,080**
Culture -DVS	0.05	0.07	0.00	0.00	0	0	0	0	1	0	0	0.00
Juice Concentrate	0.00	0.30	0.00	0.00	0	0	0	0	0	1	0	0.00
Citric Acid	0.04	0.03	0.00	0.00	0	0	0	0	0	0	1	0.00
Cost	**94.1**	**331.8**	**222**	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**(75,600)**

Source: Authors' Computation, May 2018

Table 4: Third Simplex tableau

Products	330ml Yoghurt	1000 ml Juice	250ml Ice cream	Limit of Availability	Surplus Variables							Solution Qty
Solution Variable	$\mathbf{X_1}$	X_2	X_3		A_1	A_2	A_3	A4	A_5	A_6	A_7	
Powdered Milk	**0.33**	0.00	0.38	600	1	0	0	0	0	0	0	**1818.18**
Sugar syrup	**0.10**	0.15	0.10	450	0	1	0	0	0	0	0	**450**
Flavour	**0.20**	0.25	0.22	150	0	0	1	0	0	0	0	**750**
Treated Water	**0.28**	0.20	0.30	810	0	0	0	1	0	0	0	**2892.85**
Culture-DVS	**0.05**	0.07	0.00	70	0	0	0	0	1	0	0	**1400**
Juice Concentrate	**0.00**	0.30	0.00	500	0	0	0	0	0	1	0	**0.00**
Citric Acid	**0.04**	**0.03**	**0.00**	**30**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**750**
Cost	**120**	350	250		0	0	0	0	0	0	0	**0**

Source: Authors' Computation, May 2018

Table 5: Forth Simplex tableau

Products	330ml Yoghurt	1000 ml Juice	250ml Ice cream	Limit of Availability	Surplus Variables							Solution Qty
Solution Variable	**X_1**	X_2	X_3		A_1	A_2	A_3	A4	A_5	A_6	A_7	
Powdered Milk	0.33	0.00	0.38	600	1	0	0	0	0	0	0	600
Sugar syrup	0.10	0.15	0.10	450	0	1	0	0	0	0	0	450
Flavour	0.20	0.25	0.22	150	0	0	1	0	0	0	0	150
Treated Water	0.28	0.20	0.30	810	0	0	0	1	0	0	0	810
Culture -DVS	0.05	0.07	0.00	70	0	0	0	0	1	0	0	70
Juice Concentrate	0.00	0.30	0.00	500	0	0	0	0	0	1	0	500
330ml Yoghurt	**1**	**0.75**	**0.00**	**750**	**0**	**0**	**0**	**0**	**0**	**0**	**25**	**750**
Cost	120	350	250		0	0	0	0	0	0	0	0

Source: Authors' Computation, May 2018

Table 6: Fifth Simplex tableau

Products	330ml Yoghurt	1000 ml Juice	250ml Ice cream	Limit of Availability	Surplus Variables							Solution Qty
Solution Variable	**X_1**	X_2	X_3		A_1	A_2	A_3	A4	A_5	A_6	A_7	
Powdered Milk	0.00	-0.2	0.38	600	1	0	0	0	0	0	0	352.5
Sugar syrup	0.10	0.75	0.10	450	0	1	0	0	0	0	0	375
Flavour	0.20	0.10	0.22	150	0	0	1	0	0	0	0	0
Treated Water	0.28	-0.01	0.30	810	0	0	0	1	0	0	0	600
Culture -DVS	0.05	0.03	0.00	70	0	0	0	0	1	0	0	32.5
Juice Concentrate	0.00	0.30	0.00	500	0	0	0	0	0	1	0	500
330ml Yoghurt	**1**	**0.75**	**0.00**	**750**	**0**	**0**	**0**	**0**	**0**	**0**	**25**	**750**
Cost	**0**	**260**	**250**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-90,000**

Source: Authors' Computation, May 2018