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PRODUCTION PLANNING IN THE NIGERIAN DETERGENT PRODUCING FIRM: A LINEAR PROGRAMMING METHOD

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Abstract
This study applied Linear programming technique to production planning problem of Detergent producing company in Nigeria. Linear Programming (LP) model was formulated. Data were analysed based on manpower cost, production cost on regular and overtime basis, overhead cost and work force, inventory cost, the materials cost, which were assumed to be proportion to the number/magnitude of the outputs. The generated LP model was solved using software named LINGO 11.0 software a member of Linear Interactive Numerical and Discrete Optimizer (LINDO) software. The results of the model revealed the awareness about a general apathy towards the use of linear programming and other mathematical or analytical techniques in production planning. Their planning attention is focused rather on the procurement of raw materials and the expansion of production capacity thus, the resultant effect of this is inadequate use of available productive capacity, and it also suggested that the monthly total cost of production could be reduced up to ₦ 2 million on an average. The sensitivity analysis showed that the results have a wide range of feasibility showing various adjustments that could be made in production planning for achieving their objectives. This analysis has shown that linear programming techniques can improve production planning performance thus, recommended as the appropriate/veritable planning tool for managers to apply in their various organizations.

Keywords: *Linear Programming, Production Planning, LINDO software, Inventory level*

1.0 Introduction

One of the key areas in operations management is production planning, this is a complex process that requires any enterprise to work out a dynamic production plan and adjusts manufacturing process rapidly (Chen, Liu & Wang, 2008) and mathematical programming is an important methodology used for production planning. The present economic realities in Nigeria have imposed on all firms the odious task of utilizing available resources not just effectively and efficiently but also prudently. Naturally, most resources are in limited supply; e. g limited supply of raw materials can force many organisations into liquidation (or exit from the country to other neighbouring countries). Some other firms produced at below full capacity of their plants, thus, there is a thoughtful need for an efficient and effective control of firms production capacity planning. For any productive business, proper management determines the specific combination of the products to manufacture during the time period. This becomes more complex as the number of variables representing the number of products to produce increases decision and control problem often does concern certain daily operations of organizations. Examples of this sort include production scheduling and inventory control facilities, maintenance, job scheduling among others. The dynamic of the buying society demands for high quality products which can compete favourable with foreign ones in a market oriented economic system like ours. In essence maximum production capacity utilization required that machine idle time is kept on the barest minimum possible for optional performance. The aim of this paper is to explore the application of linear programming models for production planning in the Detergent manufacturing organization in Nigeria with the view to establishing how

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linear programming model and the use of LINGO software could contributes to optimal production planning in an organization. This aim points out some questions which are:

(1) To what extent does the company at present practically apply operations research techniques in its production planning?
(2) What is the relevance of linear programming in the production capacity planning in the company?
(3) What are the appropriate measures for effective production planning for the company?

This study explored the use of linear programming models for production planning of detergent manufacturing organisations in developing country like Nigeria. It also showed how this technique has contributed to the production planning of the organisation by minimising the production cost of the products or maximising the profit earned by the company.

2.0 Literature Review

2.1 The Concept of Production Planning

The production plan is a statement of the planned rate of production expressed in aggregate terms. The plan is the focal point for integrating the manufacturing operations of the company with its business and marketing plans. Production planning is a basic function of manufacturing management applicable in all manufacturing companies in which it shows the direction and coordination of firms' resources towards attaining their prefixed goals (Kumar and Suresh, 2008).According to Wild (1997), production planning is the determination, acquisition and arrangement of all facilities necessary for future production of items. In other words, production planning is essentially a preproduction activities associated with the design of the production system. The production system is considered to incorporate an organizational element in addition to physical facilities; therefore, production planning is concerned with organizing the production of an item prior to the commencement of production. Production planning has to do with fixing the production goals and to estimate the resources required to achieve these goals. It prepares a detailed plan for achieving the production goals economically, efficiently and in timely.

2.2 The Concept of Linear Programming

Linear Programming is that branch of mathematical programming which is designed to solve optimization problems where all the constraints as well as the objectives are expressed as linear function. It was developed by Dantzing in 1947. Its earlier application was solely related to the activities of the second' World War. However soon its importance was recognized and it came to occupy a prominent place in the industry and trade. Linear Programming is a technique for making decisions under certainty i.e.; when all the courses of options available to an organisation are known and the objective of the firm along with its constraints are quantified. That course of action is chosen out of all possible alternatives which yield the optimal results. Linear Programming can also be used as a verification and checking mechanism to ascertain the accuracy and the reliability of the decisions which are taken solely on the basis of manager's experience without the aid of a mathematical model. Linear programming is the name of a branch of applied mathematics that deals with solving optimization problems of a particular form. Linear programming problems consist of a linear cost function (consisting of a certain number of variables) which is to be minimized or maximized, subject to a certain number of constraints. The constraints are linear inequalities of the variables used in the cost function. The cost function is also sometimes called the objective function. Linear programming is closely related to linear algebra; the most noticeable difference is that linear programming often uses inequalities in the problem statement rather than equalities.

2.3 Related Studies on Production Planning and Linear Programming

Studies on the application of linear programing models to production planning of manufacturing firms are limited generally, those related include; Adebiyi, Amole and Soile (2014) who explored the use of linear programming techniques for product mix optimization of paint production in Nigeria. The product mix optimisation was obtained by evaluating the mathematical programming model using LINDO computer software, the solution of which included the sensitivity analysis. The result of the analysis showed that only two out of the five products under consideration are profitable. It also revealed the rate to which the company needs to reduce cost incurred on the three other products before making them profitable for production. Balogun,

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Jolayemi, Akingbade and Muazu (2012) made use of linear programming technique to maximise the profit of a soft drink company of Nigeria Bottling Company Ilorin plant Nigeria. The linear programming model was formulated for the company and it was analysed using the simplex method, the result revealed that two particular products should be produced 50cl Coke and 50cl Fanta Orange. Their production quantities indicated 462,547 and 415,593 crates respectively with a maximum profit of ₦263,497,283.this implied that they have contributed immensely to the profit of the company.

Ezema and Amakom (2012) applied Linear programming technique to a golden plastic industry to seek and arrive at the optimal product mix of the productive firm in Emene Industrial layout. The result shows that only two sizes of the total eight "PVC" pipes should be produced. The study succeeded in establishing that Golden Plastic Industry Limited, Emene should produce 114,317.2 pieces of 25mm by 5.4m conduit pipes and 7,136.564 pieces of 20mm by 5.4m thick pressure pipes, and zero quantities of the rest sizes of pressure pipes per month in order to obtain a maximum profit of N1, 964,537 given the present level of available funds and the technical coefficients of the products. The study also showed that only two of the raw materials and labour time-were surplus, while the other six-resin, calcium carbonate, stabilizer, cast, carbon black and blend-were scarce in relation to the formulated model. The shadow prices of the raw materials obtained showed their unit contribution to the objective function (profits) and suggests to management the prices at which they should either be bought or sold. Kissani and El-Mokrini (2012) presented a comparative analysis related to the impact of social and economic factors on building reliable aggregate plans for companies operating in an international framework. The comparison is carried out between facilities of an international cement company, located in two different countries, a developing country and a developed one, namely Morocco and Belgium. The comparison is based on their aggregate planning and computational results based on profitability.

Khan, Bajuri and Jadoon (2011) estimated the optimal production level of different product manufactured at ICI a multi-national company in Pakistan. A revised simplex method was used to maximise the profit generated in 2010 subjected to some resource constraints. . Four different products manufactured at the company were taken into consideration. The analysis predicted that the production of Soda Ash is contributing more than other products to the objective function. The company is already a prime supplier of the Soda Ash in the region. The sensitivity analysis reveals the fact that a cost of R.s 1 spent as the cost of the goods sold returns at the rate of R.s 0.176. The company can save profits of R.s 189,708, R.s 989,238, R.s 15,594,377 and R.s 45,408,040 by changing its production space within the first, second, third and fourth digits respectively. The research revealed that among the other products Soda Ash is more profitable to the company and the company should give more attention to its production to maximize its profit. Mula, Poler,Garcia-Sabater and Lario (2006) added the consideration of uncertainty and explained how to use artificial intelligence models in aggregate planning and simulation as well as uncertainty. The work demonstrated other variants of aggregate planning called the hierarchical production planning and material requirement planning by using analytical models, conceptual models and artificial intelligence models in addition to simulation models.

Yenradeea, Pinnoi and Charoenthavornying (2001) addressed demand forecasting and production planning for a pressure container factory in Thailand, where the demand patterns of individual product groups are highly seasonal. Three forecasting models, namely, winter's, decomposition, and Auto-Regressive Integrated Moving Average (ARIMA), were applied to forecast the product demands. The results were compared with those obtained by subjective and intuitive judgements (which were the current practice). It is found that the decomposition and ARIMA models provide lower forecast errors in all product groups. As a result, the safety stock calculated based on the errors of these two models is considerably less than that of the current practice. The forecasted demand and safety stock are subsequently used as inputs to determine the production plan that minimizes the total overtime and inventory holding costs based on a fixed workforce level and an available overtime. The production planning problem is formulated as a linear programming model whose decision variables include production quantities, inventory levels, and overtime requirements. The results reveal that the total costs could be reduced by 13.2% when appropriate forecasting models are applied in place of the current practice.

Homburg (1996) modelled a production planning model for decentralized organization. The model was formulated as a linear program with multiple objectives. Lee, Chew and Ng(2005) used production planning model to develop an optimal production schedule for a manufacturer of hard-disk drives. Liu and Tu (2008) solve a production planning problem where the production quantity is limited by inventory storage capacity. The problem further assumes that stock outs are allowed and that inventory storage capacity is constant. Huang and Xu (1998) transformed the multi-stage, multi- item aggregate scheduling problem into a static job-assignment problem using Frank Wolfe algorithm to solve their modified problem. Qiu and Burch (1997) modelled a

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hierarchical production planning problem for a yarn-fiber facility. Kanyalkar and Adil (2005) formulated a linear programming model for an integrated multi-item, parallel multi-plant production and dynamic distribution problem. It also considered safety stocks and capacity aggregation to minimize the effect of uncertainties in demand and supply. Although studies has shown that the linear programming technique has been applied in various industries in developed and developing countries but there is rarity of studies that has applied this technique to the production planning of a manufacturing organisation with the view of minimising the cost of production of their products especially in developing country like Nigeria which this study sets out to do.

3.0 Research Methods

3.1 Research Design

The personal interview methods were used to obtain information and data about production planning in a company through the records of production plans were equally accessed. The employees interviewed were all the managers involves in the production planning. They are the general managers, the assistant general manager, and the head of departments of laboratory, administration, production, engineering, account store and planning officer. The information obtained was to know the planning process and tools used in the company. This information also revealed the awareness and use of linear programming in their planning of operations.

3.2 Characteristics of Production Planning Problem

The linear programming formulation of production planning problem, this study used a short term (one year) linear programming model to determine the production requirement for the planning period. The production requirement are the level of regular or overtime production, level of inventory used and how the labour were allocated to these activities so that an objective such as minimisation of cost can be achieved.

3.2.1 Definition of Decision Variables

Let X_t = number of units produced on regular time in month (t)
Y_t = the number of units produced on overtime in month (t)
I_t = inventory in units at the end of the month (t)
TC = total cost incurred

3.2.2 Definition of Parameters

D_t = demand in units in month (t)
S_t = required safety stock in units in month (t)
K_{Xt} = production capacity on regular time in unit month (t)
K_{Yt} = production capacity on overtime in unit month (t)
C_1 = cost of producing one unit on regular time
C_2 = cost of producing one unit on overtime
C_3 = inventory carrying cost per unit in inventory at the end of the month.
N = number of months in the planning horizons

3.3 Model Building

Stating the objective function

The objective function will be to minimize the total cost given by:
Minimize $TC = \sum (C_1X_t + C_2Y_t + C_3I_t)$
For t = 1 to 12

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Constraints

Demand Constraints

This first set of constraint provides a series of material balance on the inventories. That is, they state that each month the starting inventory plus regular production plus subcontracting minus demand equals the ending inventory.

$X_t + Y_t + I_t = D_t$ for t = 1,2,………12

Production Capacity Constraints

There are capacity constraints on the amount that can be produced on regular time, on overtime.
$X_t \leq K_{Xt}$ for t=1,2,…………12
$Y_t \leq K_{Yt}$ for t=1,2,…………12

Ending Inventory /Safety Stock

The ending inventory must be greater than or equal to the required safety stock.
$I_t \geq S_t$ for t = 1,2,…………12
All variables follows the Non-Negativity assumption of Linear programming.
The planning period is twelve months so the number of decision variables is 12 * 3= 36. The number of constraints is 12 * 4 =48.

3.4 Techniques used for Model Solution

In solving model of production planning problem for the company, linear programming LINGO 11.0 software packages was employed to minimize the total cost of production of the company. The method is quite flexible that various additional constraints can be added to take into account other limited resources or management policies. The solution also provides additional valuable information like the dual prices associated with the constraints.

4.0 Data Presentation Analysis and Interpretation

This section analyses the data collected from the company through production and process planning groups; the sales, production and operational reports. The data provided information on the planning processes and techniques used. This information in addition with the sales and other operating data were analysed to provide estimates for the linear programming model parameters. The aggregate production plan was obtained by solving the linear programming model on the computer, the solution of which included the sensitivity analysis.

4.1 Current Production Planning Practice

A formal production planning system is in the operation in the company. The General Manager heads the production planning committee. The committee members are: Sales and Operations Planning Executives (Sales and Marketing), Demand fulfilments' Manager (Logistics), Production Processing Manager (Manufacturing), they are all educated in their various discipline and some of them are aware of Linear Programming techniques but do not use linear programming in their planning. The main reason is that there is no motivation to use operations research techniques, since every bags produced is sold with little or no competition, they lack the technical expertise to apply operations research software. There is no systematic method of determining the cost and efficiency of their operations. However, the use of planning committee enables the utilization of the knowledge and skill of an interdisciplinary team to provide management with some operating solutions. Their attention is therefore focused rather on the procurement of raw material and expansion of raw material and expansion of production capacity. Since the solution thus obtained are not quantifiable. It is difficult to say whether or not they are optimum. Management does not subject their planning decisions to any scientific formulation and systematic test. Decisions are based purely on intuition and experience.

The committee is responsible for preparing the production plan. The committee meets weekly to review the production plan. A store manager who reports to the General Manager has a subordinate, a production

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planning officer. The planning officer receives the daily production report of the overall picture of the state of the production to the planning committee. The report furnishes data like actual production, delays, stoppages and material shortages in other to support the production plan maintenance and material requirement plans are also developed. Thus the hub of this analysis is to apply scientific method to production planning. In Nigeria, many of our organizational units are managed by experienced but not professionally trained people; they do not have the benefit from applying modern tools of management, where they do, they may not use them. But, in an era of globalization, these industries should not neglect the use of modern scientific and proved techniques in taking decisions pertaining to allocation of scarce and limited resources in production and sale of different products which would enable them not only to be cost efficient, earn profit but also help them provide better service to the society.

4.2 Production Plan

The production plan is based on the forecast of the sales at the beginning of the year. The demand for cartons outstrips facilities. The company products sales are therefore limited only by its production capacity and hence sales forecast is merely the production capacity forecast. The production plan is based on 80% of the production capacity. This production plan is divided equally within the year into daily, weekly and monthly targets. As a matter of policy, the company plans to maintain even daily production throughout the year. It allows a 2 week break to facilitate a general overhaul of the machinery and allow production operatives to take two weeks annual leave. The consequence of this policy is a 2 shift working system of 24 hours a day, with 8 hours regular and 4 hours overtime per day, 6 days working week, (Monday- Saturday) and regular production hours available per employee is 40hours regular and 44hours overtime. Based on these;

(i) Daily production is 14,133 cartons per day in regular time
(ii) Daily overtime production 7,067 cartons per day on overtime
(iii) Weekly Production is 84,798 cartons per week in regular time
(iv) Weekly production is 42,402 cartons per week on overtime

Production reports are maintained to record actual production and are reviewed weekly to ensure compliance with plans. Management is pleased if production exceeds targets but if there is short fall, additional overtime work is scheduled for Sundays to make up.

4.2.1 Raw Material Plan

The raw materials are procured locally and some are imported, a store manager monitors the level of the raw materials that are available and advises management as to when to order and quantity to replenish stock in order to meet the projected production. The two bin system is generally used. Under this system, the balance in stock is checked after every issue and as soon as the balance falls below the reorder level, an order is placed. A simple EOQ model would provide better result. The reorder level is depending on whether the item is imported or produced locally. If the items are imported materials the order is placed when the stock have fallen below three months production utilization rate, while for locally produced item is one month of daily usage.

4.2.2 Maintenance Plans

The maintenance plans is based on the individual equipment manufacturer schedules. However, some schedules have modified based on the actual /operational experiences. A stock of spare parts is maintained to support the maintenance plan. The spare parts are categorized into consumable, insurance spare parts and locally fabricated parts. The procurement procedure is similar to those applicable in the raw material process. The maintenance personnel assist the store manager in monitoring and requesting maintenance spares. The reorder level is however, related to the special nature of the spares and the fabrication method. The objective is to maintain minimum spares necessary to support their maintenance activities and production plans.

4.3 The capacity data were obtained from the 2015 operating year.

(i) The total cost of producing a unit during regular time (C_1) is ₦ 730.6997
(ii) The total cost of producing a unit during overtime (C_2) is ₦ 365.3489
(iii) The overhead cost of producing a unit on regular time (C_1) is ₦ 61.6075
(iv) The overhead cost of producing a unit on overtime basis (C_2) is ₦ 30.8038

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(v) Inventory carrying cost per unit C_3: This cost obtained as an estimate from the store and account departments as 5 % of the production cost. The production cost of producing a product is ₦ 1096.04666
(vi) Daily working hours per employee = 12 hours
(vii) Regular production hours available per employee per month (t) are obtained by multiplying the number of normal working days and the number of working hours per day.
(viii) The overtime production hours available 44 hours B_t is obtained by multiplying the number of Saturday in a week/month and daily working hours per day.
(ix) Production capacity on regular time in unit per day in regular Kx_t =14,133 cartons
(x) Production capacity on overtime in unit per day in overtime Ky_t = 7,067 cartons
(xi) Initial number of employees = 188 workers
(xii) Initial inventory in units = 248088kgs
(xiii) Number of man hours required to produce one unit K production capacity per month= 188 peoples
(xiv) Total number hours available per month = Number of employees * Daily working hours * Number of days in the month: 188*12*30 = 25560 hours

The data collected from the production planning of a hypothetical company is illustrated in the Table 4.1:

Table 4.1: Monthly Demand Supply Alignment (Tons) from June 2014 –May 2015

Month	,000tons Supply plan	,000tons Capacity	,000 Average weekly output	,000 Current Demand Plan	,000 Depot Stock inventory	,000 Average weekly sales	,000 Average weekly supply	Weeks cover
June 2014	3275	5400	1350	1181	2791	295	819	3
July 2014	3390	5400	1350	3309	2873	848	848	3
August2014	4020	6750	1350	4053	2839	804	804	3
September2014	3901	5400	1350	3776	2964	975	975	3
October 2014	3797	4725	1181.25	3529	3232	949	949	3
November2014	5425	6750	1350	4930	3728	1085	1085	4
December2014	4309	4725	1181.25	4712	3324	1077	1077	3
January 2015	4321	4725	1181.25	3796	3849	1080	1080	4
February 2015	4681	6750	1350	4989	3541	936	936	4
March 2015	3684	5400	1350	3863	3362	921	921	
April2015	3555	4725	945	3611	3306	711	711	
May 2015	4141	6750	1350	4393	3054	828	828	

Source: Researcher field Survey, (2015)

Since the figures given in the Table 4.1 are in tons and kilograms, we convert it to bags by dividing the figures by 11.25kg as prescribed to know the monthly production of the product to be produced whether on regular time or overtime basis, the production capacity, and the inventory in units. This calculation is given the Table 4.2; In column one of the Tables 4.2 which represent the supply plan the figures under this column would be divided by 11.25kg, to enable us to know the total monthly production for the various months. To determine the number produced on regular and overtime, we calculate it based on the number of hours on regular time which is 16hours/day, and 8 hours on overtime.

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Table 4.2: The Production Plan for the months (Regular and Overtime)

Months	Supply Plan in tons	Divided by 11.25	Total Produced in (bags)	% produced on Regular time (67%)	% produced on Overtime (33%)
June 2014	3275000	11.25	291111	194074	97037
July 2014	3390000	11.25	301333	200889	100444
August 2014	4020000	11.25	357333	238222	119111
September2014	3901000	11.25	346756	231170	115585
October 2014	3797000	11.25	337511	225007	112504
November2014	5425000	11,25	482222	321481	160741
December 2014	4309000	11.25	383022	255348	127674
January 2015	4321000	11,25	384089	256059	128030
February 2015	4681000	11.25	416089	277393	138696
March 2015	3684000	11.25	327467	218311	109156
April 2015	3555000	11.25	316000	210667	105333
May 2015	4141000	11.25	368089	245393	122696

Source: Authors` Elaboration, (2015).

In column 2, 4 and5 of the Table 4.3 which represent the maximum production capacity for the months, the current demand plan for the month(s) and inventory in stock respectively. These figures in these columns will also be converted into bags to know the maximum capacity to be produced, demanded, and the inventory.

Table 4.3: Production capacity data for Linear Programming analysis

Months	Production Capacity (Tons)	Divided by 11.25	Total Produced in (bags)	Current demand (Tons)	Divided by 11.25	Demand for the months	Inventory in Units (Tons)	Divided by 11.25	Inventory in units (bags)
June 2014	5400000	11.25	480000	1181000	11.25	104978	2791000	11.25	248088
July 2014	5400000	11.25	480000	3309000	11.25	294133	2873000	11.25	225377
August 2014	6750000	11.25	600000	4053000	11.25	360267	2839000	11.25	252355
September 2014	5400000	11.25	480000	3776000	11.25	335644	2964000	11.25	263466
October 2014	4725000	11.25	420000	3529000	11.25	313689	3232000	11.25	287288
November 2014	6750000	11,25	600000	4930000	11,25	438222	3728000	11,25	331377
December 2014	4725000	11.25	420000	4712000	11.25	418844	3324000	11.25	295466
January 2015	4725000	11,25	420000	3796000	11,25	337422	3849000	11,25	342133
February 2015	6750000	11.25	600000	4989000	11.25	443467	3541000	11.25	314755
March 2015	5400000	11.25	480000	3863000	11.25	343378	3362000	11.25	298844
April 2015	4725000	11.25	420000	3611000	11.25	320978	3306000	11.25	293866
May 2015	6750000	11.25	600000	4393000	11.25	390489	3054000	11.25	271466

4.3 Production planning model of a detergent producing company for the period of June 2014 to May 2015;

Model;

Minimize (Total costs of Production): $730.6997\ X_1 + 730.6997\ X_2 + 730.6997\ X_3 + 730.6997\ X_4 + 730.6997\ X_5 + 730.6997\ X_6 + 730.6997\ X_7 + 730.6997\ X_8 + 730.6997\ X_9 + 730.6997\ X_{10} + 730.6997\ X_{11} + 730.6997\ X_{12} + 365.3489\ Y_1 + 365.3489\ Y_2 + 365.3489\ Y_3 + 365.3489\ Y_4 + 365.3489\ Y_5 + 365.3489\ Y_6 +$

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$365.3489 Y_7 + 365.3489 Y_8 + 365.3489 Y_9 + 365.3489 Y_{10} + 365.3489 Y_{11} + 365.3489 Y_{12} + 54.802 I_1 + 54.802 I_2 + 54.802 I_3 + 54.802 I_4 + 54.802 I_5 + 54.802 I_6 + 54.802 1_7 + 54.802 I_8 + 54.802 I_9 + 54.802 I_{10} + 54.802 I_{11} + 54.802 I_{12}$

Subject to

Monthly Regular Production Capacity Constraints;

June 2014) $X_1 \geq 320000$
July 2014) $X_2 \geq 320000$
Aug 2014) $X_3 \geq 400000$
Sep 2014) $X_4 \geq 320000$
Oct 2014) $X_5 \geq 280000$
Nov 2014) $X_6 \geq 400000$
Dec 2014) $X_7 \geq 280000$
Jan 2015) $X_8 \geq 280000$
Feb 2015) $X_9 \geq 400000$
Mar 2015) $X_{10} \geq 320000$
Apr 2015) $X_{11} \geq 280000$
May 2015) $X_{12} \geq 400000$

Monthly Overtime Production Capacity Constraints;

June 2014) $Y_1 \geq 160000$
July 2014) $Y_2 \geq 160000$
Aug 2014) $Y_3 \geq 200000$
Sep 2014) $Y_4 \geq 160000$
Oct 2014) $Y_5 \geq 140000$
Nov 2014) $Y_6 \geq 200000$
Dec 2014) $Y_7 <= 140000$
Jan 2015) $Y_8 \geq 140000$
Feb 2015) $Y_9 \geq 200000$
Mar 2015) $Y_{10} \geq 160000$
Apr 2015) $Y_{11} \geq 140000$
May 2015) $Y_{12} \geq 200000$

The demand constraints

June 2014) $X_1 + Y_1 - I_1 = 104978$
July 2014) $X_2 + Y_2 + I_1 - I_2 = 294133$
Aug 2014) $X_3 + Y_3 + I_2 - I_3 = 360267$
Sep 2014) $X_4 + Y_4 + I_3 - I_4 = 335644$
Oct 2014) $X_5 + Y_5 + I_4 - I_5 = 313689$
Nov 2014) $X_6 + Y_6 + I_5 - I_6 = 438222$
Dec 2014) $X_7 + Y_7 + I_6 - I_7 = 418844$
Jan 2015) $X_8 + Y_8 + I_7 - I_8 = 337422$
Feb 2015) $X_9 + Y_9 + I_8 - I_9 = 443467$
Mar 2015) $X_{10} + Y_{10} + I_9 - I_{10} = 343378$
Apr 2015) $X_{11} + Y_{11} + I_{10} - I_{11} = 320978$
May 2015) $X_{12} + Y_{12} + I_{11} - I_{12} = 390489$

Ending Inventory

June 2014) $I_1 \geq 248088$
July 2014) $I_2 \geq 225377$
Aug 2014) $I_3 \geq 252355$
Sep 2014) $I_4 \geq 263466$
Oct 2014) $I_5 \geq 287288$
Nov 2014) $I_6 \geq 331377$
Dec 2014) $I_7 \geq 295466$
Jan 2015) $I_8 \geq 342133$
Feb 2015) $I_9 \geq 314755$
Mar 2015) $I_{10} \geq 298844$

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Apr 2015) $I_{11} \geq 293866$
May 2015) $I_{12} \geq 271466$
End

Note: let X_j represent production of bulk detergent family products produced on regular basis.
Let Y_j represent production of bulk detergent family products produced on overtime basis.
Let I_j represent inventory in units for production of bulk detergent family products produced for both regular and overtime basis.
Where j =(1,2,3,4,5,6,7,8,9,10,11,12) months of productions planning.

Insert Table 4. 4 (See Appendix)

4.4 Result of Data Analysis

The production planning problem of the detergent producing company formulation of the linear programming model in this study covers a planning horizon of twelve months (June, 2014 to May, 2015) and for bulk detergent family products (soaps).Currently, the company production planning factory spent close to ₦10billion (Ten billion Naira) in the yearly production of bulk detergents products. However, the LINGO 11.0 Software used for solving the production plan model suggested the better production plan on how to reduce the total production cost of bulk detergent up to the tune of an average of ₦ 27,231,444 (twenty seven million, two hundred and thirty one thousand, four hundred and forty four million naira) per year. Similarly, with the current monthly total cost of production of ₦736, 543,315.The LINGO 11.0 software used for analysing the production planning problem in the organization also suggested that the monthly total cost of production should be reduced by ₦ 2,269,287 on an average.

4.5 Sensitivity Analysis

The software took thirteen (13) iterations to solve the production planning problem of the company. The value column shows zero indicating that under the present production plan of hypothetical company shows that the very first month (June, 2014) under production was not optimal, the material resources were not use efficiently, the company used all the resources for production in the first month which is June 2014 on regular time basis under consideration. However, the reduced column of the June 2014 value suggested the rate to which the company should improve on the use of the resources available to achieve the objective of minimizing the total cost of production to the minimal level, of which application of linear programming in this regard is of good assistance to decision makers. In addition, the reduced cost column in the output of the model suggested the rate to which the current cost of production on the monthly basis has to be reduced in order to minimize current the total cost of production of bulk detergent products optimally. It also shows how much the objective function coefficient of each of the decision variable would reduce before it would be possible for that variable to assume a positive value in the optimum solution. This explains the rate at which the current cost of production on monthly basis has to be reduced in order to reduce the total cost of production of the bulk detergent.

(i) Regular, the production cost on regular time must be reduced by 54, 802 before production can be optimal.
(ii) Inventory, the inventory cost which is 5% of production cost remain as 54.802 for the month of July, 2014 to April, 2015 except for inventory cost for the month of May, 2015 which has accumulated to 7,855,017.

Furthermore, the surplus column of the LINGO 11.0 output suggested the rate of inventory unused for production. The implication of this is that; it shows the rate at which the company tie down capital on those inventory idle or unused which could have been used for other production.

(i) Under regular production capacity constraint, the unused inventory, are for the month of July, 2014 of 320000bags, August, 2014 = 240,889 bags, September, 2014 =2397333bags, October, 2014 =144356 bags, November, 2014 = 106311 bags, December, 2014 = 161778 bags, January, 2015= 1156 bags, February, 2015 = 82578 bags, March, 2015 = 156533 bags, April, 2015= 136622 bags, May, 2015 = 99022 bags.
(ii) Under the overtime production capacity constraint the unused inventory was on the month of June 2014 which is 209511bags.
(iii) Under the inventory constraints the unused inventory are for months of June 2014 to May 2015 which are highlighted below, June 2014 = 193066 bags, July 2014 = 225377 bags, August 2014 = 252355 bags, September 2014 =263466 bags, October 2014=287288bags, November, 2014=331377bags,December,2014=295466bags,January, 2015 =342133bags, February, 2015 =314755bags, March, 2015=298844bags, April, 2015 = 293866 bags, May, 2015 =271466 bags.

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The surplus column in the LINGO 11.0 output for production planning problem tells us how closely the company was able to satisfy the demand constraints as equality. This quantity greater than sign constraints is called Surplus. If the constraints exactly satisfy as equality the slack or surplus value would be zero. If constraints are violated as in an infeasible solution the slack or surplus value will be negative. Thus in the result under consideration all the months reports a positive values which means that the requirement of varying month are not fully met in the production plan of the company.

Dual Price

The LINGO 11.0 software solution also gives a dual price values for each of the constraints. This is the amount that the objective of minimizing the total cost would have to be reduced further if one unit of resources used in production is added to right hand side value. Thus, from the result, it revealed that if there is an increase in the right hand side value of the demand constraint for each of the month the values suggested by the LINGO 11.0 output for every month shows the cost implication of the organization inability to fulfil the demand requirement considering the resources available and the current production plan, this has a negative implication on the cost of production for each of the month and the goodwill of the organization in the face of the customers. The objective function of reducing the total cost of production in each of the month will further decrease the total cost of production by the amount of the dual price. However, since the production planning problem of the company is total cost minimization, the objective value will decrease if the company is able to increase the right hand side values of each of the constraints with positive dual prices. But, in some months of our output solution under the demand constraints, there is a negative dual price which indicates that the solution is not optimal. In June, 2014 is -67.58977 and for other months we have -73.06997 Naira only. Dual prices figures of the months indicate the rate of idleness in the use available resources during the planning horizon at that particular company under consideration thus, the outcome of this research work corroborate with the view of Iyiegbuniwe (1987) that linear programming when applied to production planning can help in eliminating indiscriminate and uneconomic inventory build-up, inefficient overtime, workforce utilization due to unsystematic production planning methods that characterized most manufacturing organizations in Nigeria. It is in light of this that, it will be of great benefit for manufacturing organizations in Nigeria to make use of operations research tools which are intellectual tools to secure improvement in their conditions by means of scientific methods. More so, the present epidemic nature of infrastructural degradation among others has imposed on all firms the task of utilizing available resources not just effectively but also efficiently and prudently. The adhoc approach to production planning as it was noted by Iyiegbuniwe (1987) was also observed by the researcher in this organization. The problem inherent in the adhoc approach to production planning still persist as includes uneconomic pile up of inventory, stock out, wasteful forces as noted were equally observed as this was more pronounce in the monthly reduction in total production costs of ₦2 million that was suggested with the use of scientific method (Linear programming model) in planning production problem.

The implication of the corroboration of Iyiegbuniwe (1987) findings and this research findings further exacerbated by the fact that most of the managers in Nigeria do not know how to use research findings, and so, cannot benefit from the results and conclusions of research. It should be borne in mind that doing research for management and solving business problems is essential in this 21st century for all organisations.

5.0 Conclusion and Implications for Management

The outcome of this research has further strengthened our knowledge that a poor planned production system result in misuse of available productive capacity. This increase the total production cost. However, in order to minimize the total production cost over the planning period, adequate planning should be carried out. This corroborate with the view of Iyiegbuniwe (1987) that application of linear programming model to production planning can eliminate indiscriminate and uneconomic inventory build-up, inefficient overtime workforce utilization and thus considerably reduce production and inventory costs. Linear programming techniques are efficient technique that can assist operation managers to plan and make the necessary decisions to allocate limited and scarce resources. Operations manager should therefore, learn how to use linear programming techniques to plan their manufacturing resources. Linear programming has been tested and found very useful in the developed, some developing countries of the world and even the production planning problem of a manufacturing company in Nigeria. Manufacturing companies should implement these processes techniques so that they can effectively utilize their production capacity and hence efficiently and more importantly manage their operations more profitably.

In conclusion, this study has demonstrated that the use of more analytical and scientific approach to production planning can be better than those practices based mainly on experience as the use of mathematical

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manipulation are now solved with the available of cheap and accessible software packages. Thus, decision makers should be aware that experience intuition and judgment are insufficient for the effective pursuit of operational objectives.

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Appendix

4.4 Model formulation Output from LINGO 11 Software

Production planning problem of a detergent producing company for the period of June 2014 to May 2015.

Objective value: 2,269,287
Infeasibilities: 0.000000
Total solver iterations: 13

Variable	Value	Reduced Cost
X_1	0.000000	54.80200
X_2	79111.00	0.000000
X_3	160267.0	0.000000

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X_4	175644.0	0.000000
X_5	173689.0	0.000000
X_6	238222.0	0.000000
X_7	278844.0	0.000000
X_8	197422.0	0.000000
X_9	243467.0	0.000000
X_{10}	183378.0	0.000000
X_{11}	180978.0	0.000000
X_{12}	190489.0	0.000000
Y_1	160000.0	0.000000
Y_2	160000.0	0.000000
Y_3	200000.0	0.000000
Y_4	160000.0	0.000000
Y_5	140000.0	0.000000
Y_6	200000.0	0.000000
Y_7	140000.0	0.000000
Y_8	140000.0	0.000000
Y_9	200000.0	0.000000
Y_{10}	160000.0	0.000000
Y_{11}	140000.0	0.000000
Y_{12}	200000.0	0.000000
I_1	55022.00	0.000000
I_2	0.000000	5,480,200
I_3	0.000000	5,480,200
I_4	0.000000	5,480,200
I_5	0.000000	5,480,200
I_6	0.000000	5,480,200
I_7	0.000000	5,480,200
I_8	0.000000	5,480,200
I_9	0.000000	5,480,200
I_{10}	0.000000	5,480,200
I_{11}	0.000000	5,480,200
I_{12}	0.000000	7,855,017

Row	Slack or Surplus	Dual Price
1	2269287	-1.000000
2	320000.0	0.000000
3	240889.0	0.000000
4	239733.0	0.000000
5	144356.0	0.000000
6	106311.0	0.000000
7	161778.0	0.000000
8	1156.000	0.000000
9	82578.00	0.000000
10	156533.0	0.000000
11	136622.0	0.000000
12	99022.00	0.000000
13	209511.0	0.000000
14	0.000000	31.05488
15	0.000000	36.53508
16	0.000000	36.53508
17	0.000000	36.53508
18	0.000000	36.53508
19	0.000000	36.53508
20	0.000000	36.53508
21	0.000000	36.53508
22	0.000000	36.53508
23	0.000000	36.53508
24	0.000000	36.53508

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25	0.000000	36.53508
JUNE, 2014 DEMAND	0.000000	-67.58977
JULY, 2014 DEMAND	0.000000	-73.06997
AUG, 2014 DEMAND	0.000000	-73.06997
SEP, 2014 DEMAND	0.000000	-73.06997
OCT, 2014 DEMAND	0.000000	-73.06997
NOV, 2014 DEMAND	0.000000	-73.06997
DEC, 2014 DEMAND	0.000000	-73.06997
JAN, 2015 DEMAND	0.000000	-73.06997
FEB, 2015 DEMAND	0.000000	-73.06997
MAR, 2015 DEMAND	0.000000	-73.06997
APR, 2015 DEMAND	0.000000	-73.06997
MAY, 2015 DEMAND	0.000000	-73.0.6997
JUNE, 2014 INV	193066.0	0.000000
JULY, 2014 INV	225377.0	0.000000
AUG, 2014 INV	252355.0	0.000000
SEP, 2014 INV	263466.0	0.000000
OCT, 2014 INV	287288.0	0.000000
NOV, 2014 INV	331377.0	0.000000
DEC, 2014INV	295466.0	0.000000
JAN, 2015 INV	342133.0	0.000000
FEB, 2015 INV	314755.0	0.000000
MAR, 2015 INV	298844.0	0.000000
APR, 2015 INV	293866.0	0.000000
MAY, 2015 INV	271466.0	0.000000

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