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Research Article

DEVELOPING OPTIMAL DECISION STRATEGIES FOR CORPORATE PROFITABILITY: A QUANTITATIVE APPROACH

*,[1]Daniel Oguche, [2]Duru Ebenezer Chika and [3]Sunday Alewo Omale

[1]Department of Banking and Finance, Veritas University, Abuja, Nigeria (TheCatholic University of Nigeria)
[2]Department of Entrepreneurial Studies, Veritas University, Abuja (The Catholic University of Nigeria)
[3]Department of Business Administration, Veritas University, Abuja (The Catholic University of Nigeria)

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ABSTRACT

The structural adjustment programme (SAP) introduced in 1986 by the military regime of General Ibrahim Babagida, the then Head of state had actually brought to the fore the problem inherent in the Nigerian economy. Nigerians had the impression that all was well and that the problem was not money but how to spend it. The inability of various Governments at various levels to tackle the problem of unemployment headlong had popularized the saying that government alone cannot provide jobs for everybody and that people should learn to be self employed. To address this challenge, this research paper attempted the application of linear programming model to the production of Maxwell table Water Company limited. The objectives of the study were to find out from theoretical analysis which of the decision making tools can be used to calculate the quantitative feasible points, to ascertain the optimizing profit level using the graphical and simplex tableau methods;to find out the raw materials of Maxwell table water company and to determine the production and space constraints. The research design chosen was the use of secondary data and content analysis. The sources of data were both primary and secondary. The analytical tool was by prose writing and content analysis. The reliability of the data stemmed from the sources that they were all published data. The validity of the data was by content analysis. An optimal solution that requires the production of 1,956 .52 bottled water and 7,200 units of sachet water with a sales revenue of ₦1, 306,173.20 per week using linear programming model was obtained. All the objectives of the study were achieved.

INTRODUCTION

The structural adjustment programme (SAP) introduced in 1986 by the military regime of General Ibrahim Babangida had actually brought to the fore the problem inherent in the Nigerian Economy. Then, Nigerians had the impression that all was well and that the problem was not money but how to spend it. Chief ObafemiAwolowo raised an alarm in 1979 about the precarious state of the Nigerian economy with respect to the phenomenal rise in unemployment which was not in tandem with the claim that money was not our problem. This problem of unemployment has been further worsened by various factors seemingly peculiar to the Nigerian situation and other third world or developing economies. These include poor planning or "excellent planning" but most times characterized by implementation difficulties owing to administrative inertia and corruption, mono economy (dependence on oil with attendant price fluctuations in the World Market) and other variables. At the moment, exchange rate of Naira (Nigerian Currency) to the Dollar as at September 10, 2016 rose N418.00 to a Dollar. This variable has had multiplier effects on virtually everything in the country. Prices of food items have skyrocketed, agitation for upward review of salaries of workers on the increase, unemployment level almost hitting the sky and crime rate almost getting out of control with kidnapping taking its toll at the local communities. The inability of governments at various levels to tackle the problem of unemployment headlong has popularized the saying that 'government alone cannot provide jobs for everybody and that people should learn to be self employed'. Before now, many people, especially the educated ones have always depended on government for employment after graduation from school (Olagunju, 2015). The story is changing today and many citizens of third world countries have began to think and look inward to be on their own rather than depending on government employment. For example, many university and college graduates have either established or are in the process of establishing their own businesses such as bread baking, water treated for drinking, commercial transportation, laundry and dry-cleaning et cetera. These are

***Corresponding author: Daniel Oguche,**
Department of Banking and Finance, Veritas University, Abuja, Nigeria (TheCatholic University of Nigeria)

right strategic decisions indeed. Federal Government has since directed all higher institutions in Nigeria to include in their curricula course instructions on entrepreneurial studies (skill acquisition). We believe that this directive has not been flaunted by any higher institution in the country and some graduates are seen in some self established businesses. However, decision making strategies are an essential part of life whether in work environment or out of it. Decision makers are those responsible for making a judgment between two or more alternatives. This exercise becomes more compelling in view of the present global economic doldrums and the primary objective of profitability of corporate outfits. This leads us to the application of linear programming to achieve this purpose. Linear programming has been described as one of the most versatile, powerful and useful techniques for making managerial decisions. It has been employed in solving a broad range of problems in business, government, industry, hospitals, libraries and education. As a technique for decision making, it has demonstrated its value in such diverse areas as production, finance, marketing, research and development as well as personnel (Loomba, 1978).

It has a wide variety of applications in the petro-chemical industries where it is used to determine the best mixture of ingredients for blending gasoline, and in agriculture for producing (at least cost) an animal feed mix with given minimum nutrient contents. Some of the many industries currently using linear programming include steel and rolling mills, food processing, paper making, brick manufacture and electrical goods.

Among other problems addressed by linear programming are:

- Production planning-deciding what goods to produce, and how much of each to produce;
- Production scheduling-deciding which jobs should go on at which machines, and in what order;
- Transportation arrangement-concerning how to convey goods to customers at least cost;
- Assignment problems-matching people with jobs, work with machines or contracts with bidders;
- Investment planning-selecting the best project on a limited budget;
- Overall corporate planning-using linear programming models that can encompass the company (Wilkes, 1989).

It's against this backdrop that the researchers seek to investigate Developing Optimal Decision Strategies for Corporate Profitability: Using a Quantitative Approach.

Objectives of the Study

The broad objective of this paper is to examine the application of linear programming as a quantitative strategic approach to corporate profitability.

The specific objectives are:

- To find out from a theoretical analysis which of the decision making tools canbe used to calculate the quantitative feasible points.
- To ascertain the optimizing profit level using the graphical and simplex tableau methods.
- To find out the raw materials for maxwell water company production.
- To determine the production and space constraints.

Research Questions

- Which of the theoretical analytical decision making tools can be used to calculate the quantitative feasible points for Maxwell Water Company?
- Can the optimizing profit level be ascertained using graphical and simplex tableau methods?
- What are the raw materials for Maxwell water production?
- Can the production and space constraints be determined?

Methodology

Content analysis and survey were employed to determine and obtain relevant data for the computation of the graphical and simplex tableau methods leading to the profitability level of Maxwell Water Production CompanyLokoja, Kogi State. The study was both qualitative and quantitative. For the primary source, interview method was applied to collect relevant data on raw materials used for Maxwell table Water Company, Lokoja, Kogi State, Nigeria as well as constraints and prices of their products. A total of one hundred questionnaires were administered to the 100 staff (40 senior and 60 junior) and collected giving a response rate of 100%. The secondary sources of data collection include textbooks, internet, and management a journals publication that provided the theoretical framework. The company produces both bottled and sachet water. Production started in 2002 and it was registered by the National Agency for Food and Drug Administration and Control (NAFDAC) the same year. Maxwell sachet water registration number was 01-0909L while those of 75cl and 150cl were 01-6627 for 2004 and 50clwas AL-5562 for 2005. There is no doubt that Nigerian industrialists whether small or large business operators are confronted with the problem of taking appropriate decision strategies that will help them to optimize certain objectives. Current global economic meltdown with the rising cost of factors of production, rising prices of both finished and unfinished goods and underutilization of plant capacity pose a serious problem to them in selecting the best approach to business decisions. In view of this state of the economy, they are likely to choose the approach that ensures business cost minimization (and, of course, profit maximization) in their operations.

Conceptual Definitions

Corporate-corporate according to Advanced Learners Dictionary of Current English by Hornby (2006) is connected with a corporation or involving or shared by all the members of a group, or belonging to or connected with a business. Decision- decision is the condition of a process designed to weigh the relative utilities of a set of available alternatives so that the most preferred course of action can be selected for implementation. Decision making involves all the thinking and activities that are required to identify the most preferred choice. In particular, the making of decision requires a set of goals and objectives, a system of priorities, an examination of alternative courses of feasible and viable actions, the projection of consequences associated with different alternatives and a system of choice criteria by which the most preferred course is identified (Loomba, 1978). Decision making according to Koontz and Weihrich (2006) is the selection of a course of action among alternatives. It is the core of planning. Linear programming-Linear programming is a powerful quantitative technique (or operational research technique) designed to solve allocation problem. The term “linear programming” consists of the two words, “linear” and “programming”. The word “linear” is used to describe the relationship between decision variables which are directly proportional. The word “programming” means planning of activities in a manner that achieves some “optimal” result with available resources. A programme is “optimal” if it maximizes or minimizes some measure or criterion of effectiveness such as profit, contribution (i.e. sales-variable cost), sales, and cost. Thus, linear programming indicates the planning of decision variables which are directly proportional to achieve the optimal result considering the limitations within which the problem is to be solved (Tulsian, 2002). Strategy-by strategy, managers mean their large-scale, future-oriented plans for interacting with the competitive environment to achieve company objectives. It is a company’s game plan. Although that plan does not precisely detail all future deployments (people, finances and material), it does provide a framework for managerial decisions. A strategy reflects a company’s awareness of how, when and where it should compete, against whom it should compete and for what purposes it should compete (Pearce II and Robinson, 1982). Akinsulire (2006) corroborates Pearce II and Robinson’s definition of strategy thus, “it is a course of action including the specification of resources required to achieve a specific objective”.

Elaborating on this definition, Ezigbo (2007) says strategy consists of actions taken by an organization to accomplish stated objectives, a set of management guidelines which specify the firm’s product market position, the directions in which the firm seeks to grow and change, the competitive tool it will employ, the means by which it will enter new markets, the manner it will configure its resources, the strengths it will seek to exploit and weaknesses it will seek to avoid. Loomba (1978) and Ewurum (2016) support the definition by Tulsian (2002). They agreed that linear programming is a general model for optimum allocation of scarce or limited resources to competing (or activities) under such assumptions as certainty, linearity, fixed technology and constant profit per unit. Profitability-The money that you make in business or by selling things, especially after paying the costs involved (Hornby, 2006). Decision strategies ostensibly commit the firm for a long time, typically five years. However, the impact of such decisions often lasts much longer once a firm has committed itself to a particular strategy, its image and competitive advantages usually are tied to that strategy.

Review of Related Literature

Characteristics of Strategic Decisions

Akinsulire (2006) outlines the following characteristics of strategic decisions:

- They are concerned with the scope of the organization’s activities.
- They must match the organization’s activities to the environment in which it operates.
- They match an organization’s activities to its resource compatibility.
- They involve major decisions about the allocation or reallocation of resources.
- They affect operational decisions because they set off a chain of “lesser” decisions and operational activities involving the use of resources.
- They are affected by (a) environmental considerations (b) resources availability and (c) the values and expectations of the people in power within the organization.
- They affect the long-term direction that the organization takes.
- Strategic decisions have implications for change throughout the organization and so are likely to be complex in nature.

Decision making as a central management activity

Decision-making is a central management activity. There are many qualities a businessman should develop for a successful operation which include among others:

- A fascination with high level business matters.
- The courage to risk a career as well as money on one’s own judgment.
- The willingness to assume responsibilities, which often leads to a degree of unpopularity.
- The art of making sound decisions.
- The ability to communicate effectively (Carlin, 1970:35).

According to Carlin, of all these qualities, the art of making sound business decisions is profitably the most important trait. One can hardly imagine a successful executive lacking this ability. At the core of decision making activity is the problem of choosing a course of action under conditions of uncertainty and ambiguity. Coping with uncertainty forms the hub of decision making, for without uncertainty as to which course of action to take, there would be no decisions to be made (Butler, 1996). In most organizations, the kinds of decisions that are made can be divided into two: programmed and non-programmed decisions (Koontzand Weihrich, 2006). A programmed decision they explain is usually applied to structured or routine problems. This kind of decision is used for routine and repetitive work and it relies heavily on previously established criteria. It can safely be referred to as decision making by precedent. Non-programmed decisions are used for unstructured, novel and ill-defined situations of a non-recurring nature. Most decisions are neither completely programmed nor completely un-programmed, they are a combination of both upper level managers who usually deal with un-programmed decisions. Problems at lower levels of the organization are often routine and well structured, requiring little or no direction by managers and other workers.

Business Environment Necessary for Decision Making

Carlin (1970) gives five business conditions which if absent would render the making of decisions both foolhardy and dangerous. These include:

- Company policies and objectives must be spelt out, if this is not so, executives will have to guess at the direction the company is supposed to be going thereby making conflicting decisions. They have no common goal, no specific targets, and no team efforts.
- Problem solving and decision-making must be welcomed by management. There are times when executives without even realizing it resist change. This is natural especially as people get older and more aware of the troubles and internal conflicts that result from change. Such an attitude can atrophy a company and hold it back from realizing its full potentials.
- The atmosphere of the business should not be threatening. A human trait that discourages decision-making is buck passing. In some organizations, when things go wrong, they look for a scapegoat. Only a man or woman of uncommon courage is willing to stick out his or her neck in making decisions when he or she knows that the superiors are waiting for an opportunity to chop off his or her neck. If decision making is going to be effective, the environment should be the one in which the decision maker is rewarded, not threatened.
- The organization should encourage the maverick rather than the organization man. Some companies seem to encourage conformity among their executives. They want what is known today as organization men, men who think, respond and make decisions in predictable patterns. Even though this may appear desirable, in actual fact, it stifles creativity and opens the door to "yes men". What companies really need are the maverick men who look at long standing practices with critical eyes.
- There must be time for problem solving. Some companies want everyone to be always busy. This results in everyone being bogged down with details. This is disastrous for decision-making because men must be free of harassment before they can think creativity.

Tools for Decision Making

There has been a steady increase in the number and diversity of quantitative decision-making tools. They come under the name operations research, which refers to manipulating and experimenting with quantitative data to determine the best solutions to operating problems (Carlin, 1970). Some of such tools are summarized below:

Research Design

This is frequently carried out by marketing and personnel research groups or organizations. They can be used in other functional areas as well. Research designs are used with samples of objects and data collected are analyzed using statistical procedures. This logic of this approach can be illustrated by using the classical or basic design for the conduct of research. Usually referred to as before and after control group design, it is used to establish whether a pre-determined change effort will in fact yield a desired result. It can be used to evaluate the effects of changes in organization structures, in payment programmes, in training procedures and for many other purposes. First a group of subjects is selected at random and a measure of what to change is taken, then whatever is being evaluated is introduced. Finally, a second measurement is taken on the change variable. If there is a definite change from pre-test, then a possibility exists that the experimental variable has been the cause. To make sure this is so, the notion of control is brought in. Another group identical to the first one in all aspects is selected and exposed to the same circumstances as the first group except that the experimental factor is not introduced. Any clear differences between the two groups at post-test must be due to the experimental variable since it is the only thing that differs. The use of research design of this kind to guarantee decisions on whether to use certain approaches, techniques and procedures may be time consuming and costly. It is used when it is the only way of determining whether a contemplated decision can in fact contribute to organizational goal attainment.

Statistical Decision Theory

An amalgam of statistics, economics and psychology, statistical decision theory is heavily relied upon by management science (Lapin, 1994). It is concerned with the evaluation of potential outcomes from various decision alternatives. It makes use of pay off matrices and decisions trees.

Payoff Matrices: The general model of a payoff matrix, is shown below.

State of nature, N_1, N_2, N_3, N_4… refers to things that might happen in future such as decline, stability and increase in the demand for a given product. They are outside the decision maker's control. These are exogenous variables. To each of these, some probability of occurrence can be assigned either on the basis of sure knowledge of subjective estimates. D_1, D_2, D_3, D_4 are various decision alternatives that a manager might follow. They are within the decision maker's control and these may include advertising, product quality and price of the product. We can have P_1, P_2, P_3 as the payoffs accruing from the various decision alternatives under the various state of nature.

General Model for a Payoff Matrix

Decision States of Nature

Alternatives

	N_1	$N1_2$	N_3	N_4
D_1	P_11	$P1_2$	$P1_3$	$P1_4$
D_2	P_21	$P2_2$	$P2_3$	$P2_4$
D_3	P_31	$P3_2$	$P3_3$	$P3_4$

Once probabilities are assigned to the various states of nature and values are assigned to the various outcomes in the matrix (there are twelve outcomes in the matrix above), it is possible to compute the expected value of the various decision alternatives. The one with the highest expected value is selected.

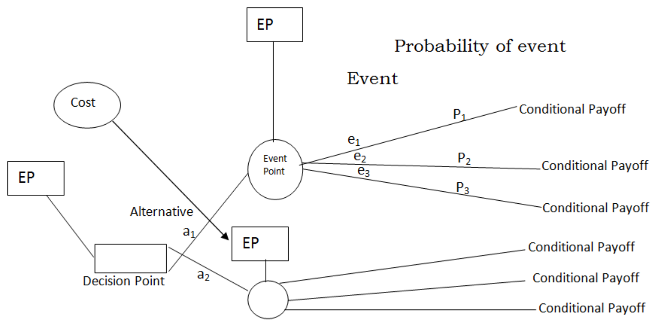
Decision-trees: A decision tree is a schematic presentation of sequential or multi-period decision-making process under risk and as such is a useful tool for evaluating sequential decision problems (Lee, 1983). He says that decision trees provide a schematic guide presentation of the following sequential processes:

Decision points: Specific points of time when a decision must be made are shown as decision points. Alternative decisions become decision branches from a square ( ) decision point.

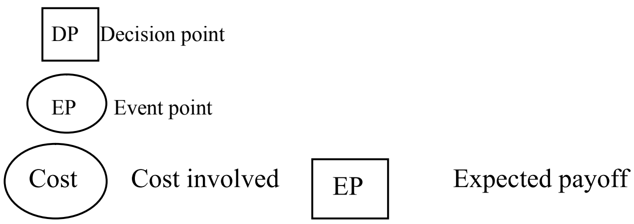
Event points: A number of states of nature that may occur are shown as event points. The possible events become event branches from a circle ( ) event point.

Probabilities: The known probabilities of events are presented above each of the event branches.

The Structure of a Decision Tree



<u>Key</u>



The structure of a decision tree, adapted from introduction to management science by Sang M. Lee, Chicago, The Druden Press.

Conditional payoffs: the conditional payoff of each eventual branch is known and recorded at the end of each branch.

Loomba (1978) and Tulsian (2000) agree that decision tree is a schematic representation of a decision problem, adding that a decision tree consists of nodes, branches, probability estimates and payoffs. There are two types of nodes: decision nodes and chance nodes. A decision node, usually designated by a square ( ), requires that a conscious decision be made to choose one of the branches that emanates from that node (i.e. one of the available strategies must be chosen). A chance node, is usually designated by a circle ( ), shows different possible events (states of nature, competitor's actions, or some other conditions) that can confront a chosen strategy. Like payoff matrices, decision trees use the product of the value of an outcome and its probability of occurrence to determine expected value. They have an added advantage as more decisions are linked together. The major difficulty in the use of decision trees as with payoff matrices is in establishing probabilities. Where possible, the preference procedure is to use historical or experimental samples so that the probabilities have a clear basis. Where uncertainty prevails, pooled judgments made by people who are in a position to know must be used. In instances where probabilities have been adequately established, decision theory does provide predictions that are superior to those derived from other more traditional approaches (Minner, 1978).

The Analysis of Waiting Lines

This predates modern operations research decades ago and has given rise to an area of mathematics referred to as queuing (Lapin, 1994). The usual objectives of a queuing model are to determine how to provide service to customers in such a way that an efficient operation is achieved. Unlike other models, a minimum cost or maximum cost profit solution is not always sought. Rather the aim of queuing model is to determine various characteristics of the waiting line. These mean values may then be used in a later cost analysis. Alternatively, a targeted level of satisfactory customer service is established, and facilities and operations are planned to meet this goal (Lapin, 1994).

Programme Evaluation and Review Technique (PERT)

Programme Evaluation Review Technique (PERT) and Critical Path Method (CPM) were developed in the late 1950's as aids in the planning, scheduling and controlling of complex, large-scale projects. PERT was developed by the U.S Navy for planning and scheduling the Polaris missile project. CPM, on the other hand, was developed by the Dupont Company and The Univac Division of Remington Rand Cooperation as a device to control the maintenance of chemical plants (Lee, 1983). In many respects, PERT and CPM are similar in their basic concepts and methodology. But there is also a basic difference between the two techniques. CPM is most appropriate for a project in which the activity durations are known with certainty. Thus, it focuses on the trade-off between the project time and cost. On the other hand, PERT is useful for analyzing a project scheduling problem in which the completion time is uncertain (probabilistic). It emphasized the uncertainties of activity completion times and attempts to reach a particular event (milestone) in a project. The PERT procedure starts with a clear statement of the objective of the project. Then a list of activities or events required to complete the project is compiled.

A sequencing of these activities is established specifying preceding and subsequent activities. Specific estimates are made of the elapsed time for completion of each activity. In PERT, three such estimates are developed for each activity to permit adequate handling of uncertainty. The time estimates are the optimistic, the most likely and the pessimistic estimates. In the Critical Path Method (CPM), uncertainty is provided for; only one time estimate, the most likely time is provided for. This is the main difference between CPM and PERT. A network diagram of activities and required times is constructed and subjected to mathematical analysis to identify those activities which when developed, will impose a delay on the completion of the project. Such activities are called critical activities. Once identified, efforts are made to shorten the time of the project. Thus, PERT is essentially a method of planning a project so as to keep the time and money spent to a minimum. It is not an optimizing procedure in the sense of identifying the best possible approach.

Linear Programme (LP)

This is the most well known operations research procedure (Lapin, 1994:41). It is an optimizing technique concerned with determining the best set of decisions given scarce resources, monetary, materials or human. Only certain types of problems are appropriate for linear programming. There are limiting assumptions in the mathematics involved and the mathematical equations required to solve a complex problem correctly are not easily formulated. Also, the objectives desired (maximum profit or minimum cost for instance) must be quantitatively definable, resources must in fact be scarce and resource alternatives must be comparable in their measurement given the requisite conditions. However, the approach can be an extremely powerful aid to management decision making.

Linear Programming (LP)

Linear programming is all about determining the best combination of limited resources to achieve a goal. It can be used only when relationships between the variables can be assumed to be linear. To comply with linearity assumption, profit per unit of each item is assumed to remain constant regardless of the level of production. It is also assumed that decision variables (that is, it's produced and resources allocated) are continuous. There is also an assumption of certainty in terms of technology and resources used. LP can thus be described as a model for optimum allocation of scarce resources to competing activities under assumptions of certainty, linearity and constant profit.

General Structure of LP Problems

Every LP problem has three parts: the objective function, a set of structural constraints and a set of non-negativity constraints (Loomba, 1978).

The Objective Function: The first step in solving an LP problem is to determine the objective of the problem which will be either to maximize profit or to minimize cost. When this objective is stated mathematically it becomes the objective function.

Set of Structural Constraints: The second step in solving any LP problem is to identify the circumstances which govern the achievement of the objective. When quantified and expressed mathematically, they are called structural constraints.

Non-Negativity Constraints: In every productive activity, a particular product is either produced or it is not produced. In other words, negative products cannot be produced. This fact is included in LP problems by stating a set of non-negative constraints.

Decision Variables: In the LP model, decision variables are elements within the problem over which the decision maker has some control. For example, a furniture maker's decision variables could be the number of chairs, tables and cupboards he can make. They are usually represented with X_1, X_2, X_3……….X_n.

Solving Linear Programming Problems

A linear programming problem can be solved by either of the following methods: the graphical method, the algebraic method, the vector method and the simplex method. Of the approaches mentioned above, the simplex method is the most general and powerful (Loomba, 1978). The algebraic and the vector approaches are in a sense the foundations on which the simplex method is built. Each method, when and if applied to a given problem, will lead to the same optimal solution. Each provides a different perspective of how a series of systematic steps leads from one solution to a "better" solution, and finally to the "best" solution. This paper shall concentrate on the two most basic methods:- the graphical method and the simplex method. The graphical method is the simpler method to use when solving LP problems and so should be used wherever possible. It however, has one limitation in its use. It can only be used when not more than two products are manufactured. The method becomes unpractical when more than two decision variables are involved. When such is the case, the simplex method is used.

A part from being a solution procedure for two products, the graphical solution has the following features:

- It can be used to solve both maximization and minimization problems.
- The "greater than or equal to" limitations (≥), the equality (=) limitations and the "less than or equal to" limitations can be dealt with graphically.
- Any number limitations can be accommodated in the graphical method.

Loomba (1978) summarizes the graphical solution procedure in this manner:

- Formulate the linear programme: A proper formulation begins with a definition of the variables that clearly describes how the symbols apply. The rest is algebraic calculation. First, the objective function is stated in an equation, followed by the expressions for the constraints. No formulation is complete without a final statement of non-negativity conditions if they apply.
- Construct a graph and plot the constraint lines: Ordinarily, this involves locating two points and connecting them. The points are usually the horizontal and vertical intercepts found on each constraint equation. But we will see that for certain constraints a different pair must be found to draw these lines.
- Determine the valid side for each inequality constraint. The simplest approach is to see whether the origin (the point of "doing nothing") satisfies the constraint by plugging its coordinates (0,0) into the inequality. If it does, then, all points on the origin's side of the line are valid and the rest are infeasible. If the origin does not satisfy the constraint, then the valid points lie on the side of the line that is opposite the origin.
- Identify the feasible solution origin: this region will be indicated by the group of points on the graph that are valid for all constraints collectively. These points correspond to the feasible plans. Ordinarily, the feasible solution region is a contiguous area lying in the positive quadrant since the non-negativity conditions preclude negative variable values.
- Plot two objective function lines and determine the direction of improvement. When profit maximization is

the goal, two profit lines will tell us the direction of increasing profit. Two lines are necessary because the direction cannot always be predicted from a single line. When the goal is to minimize cost, two cost lines are plotted. In this case, the direction of the improvement is a decrease in cost.

- Find the most attractive corner by visual inspection. This corner will be the last point in the feasible solution region touched by the profit or cost line, which is formed by sliding a straight ledge in the direction of improvement while holding it parallel to two original objective lines.
- Determine the optimal solution by algebraically calculating coordinates of the most attractive corners. The optimal solution is often represented by the intersection of two constraint lines.

However, it might also be denoted by the coordinates of a corner point formed by the horizontal or vertical intercept of one constraint equation. When this is the case, the algebraic calculations have already been performed and the optimal solution may be read directly from the coordinates shown on the graph without error. Determine the value of the objective function for the optimal solution. This is found by substituting the optimal variable values into the profit or cost equation. No solution is complete until maximum value of profit or the minimum value of cost is stated.

Lee (1983) also summarizes the simplex method in this manner:

- Formulate the linear programme in a standardized format. Add slack variables to the problem, eliminating inequality constraints. Construct the initial simplex tableau, using slack variables in the starting basic variable mix.
- Find the Zj (sacrifice) row and the Cj-Zj (improvement) row.
- Apply the entry criterion. Find the current non-basic variable that increasing its value from zero will improve the objective at the greatest rate, breaking any ties arbitrarily. This variable is the entering (incoming) variable. Mark the top of its column (the key column) with an arrow. If no improvement can be found, the optimal solution is represented by the present tableau.
- Apply the exit criterion. Use the current tables exchange coefficient values form the key column to calculate the following exchange ratio for each row:

Solution Value (quantity)

Exchange Coefficient

- Construct a new simplex table. Replace the basic mix label of the existing variable with that of the entering variable. All other basic variable mix labels remain the same. Also, exchange the unit profit (unit cost) column value to correspond to the newly entered basic variables. Then re-compute the row values to obtain a new set of exchange coefficient applicable to each basic variable.
- Go back to step (b)

The simplex method is an interactive procedure that takes us from the worst solution to the best, each succeeding solution being better than the one before it. The procedure tells us when the optimal solution is reached. This occurs (for maximization) when all the values in the Cj-Zj (improvement) row are either zero or negative, showing no further improvement is possible. When the objective is minimization of cost, an optimal solution is obtained when the net evaluation row (Cj-Zj) is zero or positive.

Calculation of Quantitative Feasible Points for Maxwell Water Company

Introduction

In order to test the possibility of applying the linear programming model to the operations of Maxwell Table Water Company Limited, the following data were collected.

Objective Function	**Selling Price**
Products	
a. Bottled water 0.50 litre bottle	#280 per carton of 12 bottles
0.75 litre bottle	#350 per carton of 12 bottles
1.50 litre bottle	#600 per carton of 12 bottles
b. Sachet of water 0.6 litre	#70 per bag of 20 sachets

The company does not maintain any record of final accounts yet. As a result, I was able to estimate the profit per unit of each product. Consequently, I decided that the objective function will be to maximize sales revenue (assuming that when sales are maximized, profit will be maximized). The corporate outfit produces two products: bottled water and sachet water.

Let X_1 = bottled water, X_2 = sachet water.

Average price/carton = $\frac{280+350+600}{3} = \frac{1230}{3} = 410$

Objective function = maximize sales revenue = $410\ x_1 + 70X_2$

Constraints

From the oral interview, the following constraints were identified:

- The man hours available
- Amount of water available
- Space Limitations

Labour Hour Constraints

Thirty (30) workers work from 8:00am to 5:00pm for six (6) days with one hour break each day. We, therefore, have total man hours available as calculated below:

30 x 8 x 6 =1,440 hours

250 cartons of bottled water are usually produced per day on the average. Therefore, to make one carton, 30 divide by 250 = 0.12 hours. 1,200 bags of sachet water are produced per day on

the average. So, one (1) bag = 30 divide by 1,200 = 0.025 hours.

Consequently, the man hour constraint is $0.12x_1 + 0.025x_2 \leq 1{,}440$

Material Constraints

The company has two tankers that bring to the factory loads of water two times each week. Each tanker load contains 12,000 gallons. If we take a gallon to be 4.5 litres, then what we have is calculated below:

12,000 x 4.5 x 2 = 108,000 litres. This is the amount of water available per week.

Bottled Water

Water is bottled in 0.50 litre, 0.75 litre and 1.50litre. on the average, each bottled water contains:

$$\frac{0.50+0.075+1.50}{3} = \frac{2.75}{3} = 0.92 \text{ litres}$$

Each sachet contains 0.06 litres, since there are twelve bottles in each carton, each carton contains 0.92 litres x 12 litres = 11.04 litres.

Each bag of sachet water contains 20 sachets, that is, 0.60 litres x 20 = 12 litres.

Therefore, $11.04x_1 + 12x_2 \leq 108{,}000$ litres

Space Constraints

As a result of space limitation, only 250 cartons of bottled water can be held at a time (per day) and 1,200 bags of sachet water per day. Therefore, we have,

$X_1 \leq 250 \times 6$ days = 1,500 cartons
$X_1 \leq 1{,}500$
$X_2 \leq 1{,}200 \times 6$ days = 7,200 bags
Therefore, $X_1 \leq 7{,}200$ bags per week.
We can state (formulate) the linear programme including objective function and constraints as follows:
Maximize sales = 410 x 70X2
Subject to $0.12x_1 + 0.025x_2 \leq 1{,}440$
$11.04x_1 + 12x_2 \leq 108{,}000$
$X_1 \leq 1{,}500$
$X_2 \leq 7{,}200$
$X_1, X_2 \geq O$ (non-negativity constraint)

Solution

Since we have formulated the linear programme, we shall attempt to solve the problem using both the graphical and simplex methods.

a.***Graphical Method***

Maximize sales:$410X_1 \times 70x_2$
Subject to$0.12x_1 + 0.025x_2 \leq 1{,}400$ (labour constraint)
$11.04x_1 + 12x_2 \leq 108{,}000$ (material constraint)
$X_1 \leq 1{,}500$ (space constraint)
$X_2 \leq 7{,}200$ (space constraint)
$X_1, X_2 \geq 0$, (non-negativity constraint)

Labour Constraint

$0.12_1 + 0.25X_2 \leq 1{,}400$ (multiply both sides by 1000)
$120X_1 + 25X_2 \leq 1{,}440{,}000$
Solving for X_1,
$\frac{1{,}440{,}000}{120} = 12{,}000$
$X_1 = 12{,}000$
Solving for X_2,
$\frac{1{,}440{,}000}{25} = 57{,}600$
$X_2 = 57{,}600$

Material Constraints

$11.04x_1 + 12x_2 \leq 108{,}000$ (multiply both sides by 100)
$1104X_1 + 1{,}200x_2 \leq 10{,}800{,}000$
Solving for X_1,
$\frac{10{,}800{,}000}{1104} = 9{,}782.61$
$\mathbf{X_1 = 9{,}782.61}$
Solving for X_2,
$\frac{10{,}800{,}000}{1{,}200} = 9{,}000$
$X_2 = 9{,}000$

Plot these figures on the graph below and calculate their coordinates with a view to finding the feasible regions and consequently the optimal solution

Feeble region border points are O, E, C, G, H, A

Border Points	X_1	X_2			
O	O	O	410(O) + 70(O)	=	0
E	O	7,200	410(O) + 70(7,200)	=	504,000
C	1,500	7,620	410(1500) + 70(7,620)	=	1,148,400
G	1,956.52	7,200	410(1,956.52)+70(7,200)=		1,306,173.20
H	2,000	O	410(2,000) + 70(O)	=	820,000
A	1,500	8,000	410(1,500) + 70(8,000)	=	1,175,000.00

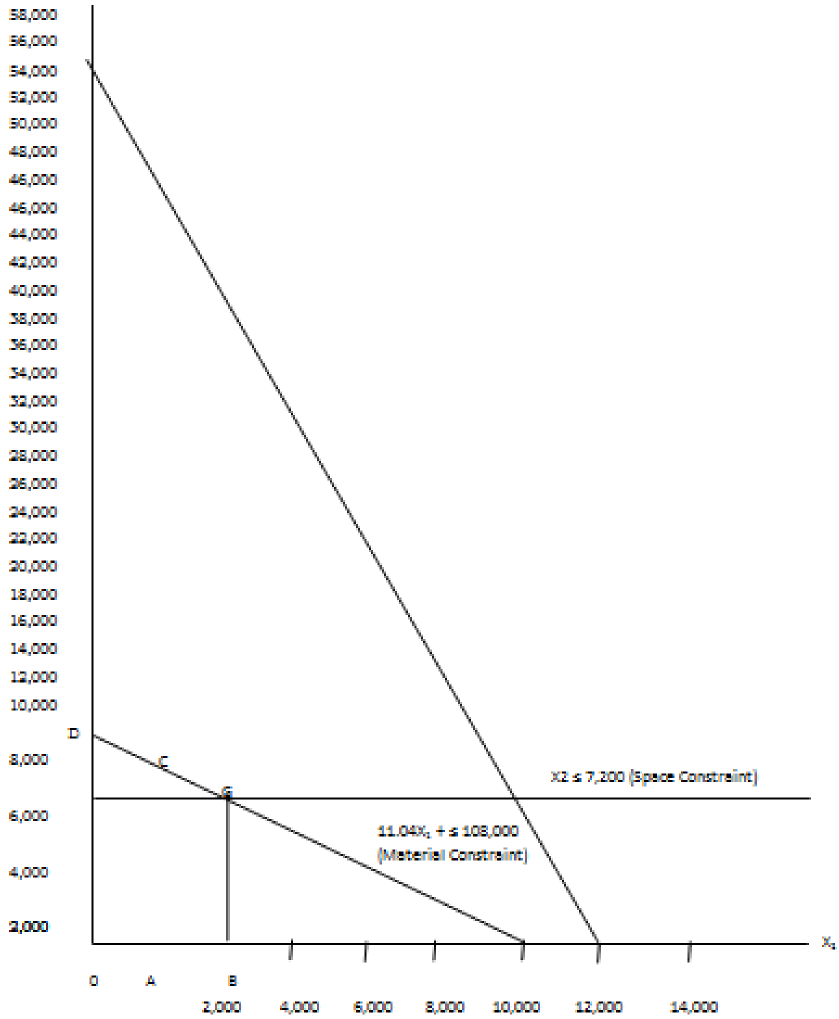
At the point C, two lines meet, so to find X_1 and X_2 coordinates at that point, we solve the two equations simultaneously. Therefore, we have:

$11.04x_1 + 12x_2 \leq 108{,}000$ (1)
$X_1 \leq 1{,}500$ (2)

Put (2) in (1),
$11.04\,(1{,}500) + 12x_2 = 108{,}000$
$16{,}560 + 12x_2 = 108{,}000$
$12x_2 = 108{,}000 - 16{,}560$
$12x_2 = 91{,}440$
$X_2 = \frac{91{,}440}{12} = 7{,}620$

At point G, $11.04x_1 + 12x_2 \leq 108{,}000$
$X_2 \leq 7{,}200$

Put (2) in (1),
$11.04x_1 + 12x_2\,(7{,}200) = 108{,}000$
$11.04x_1 + 86{,}400 = 108{,}000$
$11.04x_1 + 108{,}000 - 86{,}400$
$11.04x_1 = 21{,}600$
$X_1 = \frac{21{,}600}{11.04} = 1{,}956.52$
Simplex Method
Max sales – $410x_1 + 70x_2$



Graphical solution to Maxwell Table Water (MTW) allocation problem

First Programme tableau 1

Bv	Cpu	QtyCj	410 X	70 Y	0 S_1	0 S_2	0 X_3	0 X_4
S_1	0	1,440,000	120	25	1	0	0	0
S_2	0	108,000	11.04	12	0	1	0	0
S_3	0	1,500	1	0	0	0	1	0
S_4	0	7,200	0	1	0	0	0	1
Zj			0	0	0	0	0	0
Cj-Zj			410	70	0	0	0	0

First Programme tableau 2

Bv	Cpu	QtyCj	410 X	70 Y	0 S_1	0 S_2	0 X_3	0 X_4	RQ
S_1	0	1,440,000	120	25	1	0	0	0	12,000
S_2	0	108,000	11.04	12	0	1	0	0	9,782.61
S_3	0	1,500	1	0	0	0	1	0	1,500
S_4	0	7,200	0	1	0	0	0	1	0
Zj			0	0	0	0	0	0	
Cj-Zj			410	70	0	0	0	0	

In coming variable

Subject to $0.12x_1 + 0.025x_2 \le 1{,}440$
$11.04x_1 + 12x_2 \le 108{,}000$
$X_1 \le 1{,}500$
$X_2 \le 7{,}200$
$X_1, X_2 \ge 0$

$410x_1 + 70x_2$
$0.12x_1 + 0.025x_2 \le 1{,}440$
$11.04x_1 + 12x_2 \le 108{,}000$
$X_1 \le 1{,}500$
$X_2 \le 7{,}200$

Working for Tableau 4

A	B	C	BC	A-B
7,200	1,500	0	0	7,200
0	$^1/_{1,500}$	0	0	0
1	0	0	0	1
0	0	0	0	0
0	0	0	0	0
1	1	0	0	1
0	0	0	0	0

Working for tableau 3

A	B	C	BC	A-B	A	B	C	BC	A-BC
1,440,000	1,500	120	180,000	1,260,000	108,000	1.500	11.04	16.560	91,4440
120	1	120	120	0	11.04	1	11.04	11.04	0
25	0	120	0	25	12	0	11.04	0	0
1	0	120	0	1	0	0	11.04	0	12
0	0	120	0	0	1	0	11.04	0	0
0	1	120	120	-120	0	1	11.04	11.04	-11.04
0	1	120	120	-120	0	1	11.04	0	0

Working for tableau 3 Continues

A	B	C	BC	A-B
7,200	1,500	0	0	7,200
0	1	0	0	0
1	0	0	0	1
0	0	0	0	0
0	0	0	0	0
1	1	0	0	1
0	0	0	0	0

Tableau 3

Outgoing variable

Bv	Cpu	QtyCj	410	70	0	0	0	0	RQ
			X	Y	S_1	S_2	X_3	X_4	
S_1	0	1,260,000	0	25	1	0	-120	0	0
S_2	0	91,440	0	12	0	1	0	0	0
S_3	410	1,500	$^1/_{1,500}$	0	0	0	1	0	1
S_4	0	7,200	0	1	0	0	0	1	0
Zj			$^{41}/_{150}$	0	0	0	410	0	
Cj-Zj			$^{61.459}/_{150}$ or 409.73	70	0	0	-410	0	

Incoming variable

Working for Tableau 4

A	B	C	BC	A-B	A	B	C	BC	A-BC
1,260,000	1,500	0	0	1,260,000	91,000	1.500	11.04	16.560	91,4440
0	$^1/_{1,500}$	0	0	0	11.04	1	11.04	11.04	0
25	1	120	0	25	12	0	11.04	0	0
1	0	120	0	1	0	0	11.04	0	12
0	0	120	0	0	1	0	11.04	0	0
-120	0	120	120	-120	-11.04	1	0	0	-11.04
0	1	120	0	0	0	1	0	0	0

Introduce slack variable and eliminate inequalities. We then have:

Maximize sales $410X_1 + 70X_2 + 0S_1 + 0S_2 + 0S_3 + 0S_4$
$120X_1 + 25X_2 + 0S_1 + 0S_2 + 0S_3 + 0S_4 = 1{,}440{,}000$
$11.04X_1 + 12X_2 + 0S_1 + 1S_2 + 0S_3 + 0S_4 = 108{,}000$
$X_1 + 0X_2 + 0S_1 + 0S_2 + 1S_3 + 0S_4 = 1{,}500$
$0X_1 + X_2 + 0S_1 + 0S_2 + 0S_3 + 0S_4 = 7{,}200$
$X_1,X_2,S_1,S_2,S_3,S_4 \geq 0$

Optimal Solution

Produce 1,956.52 units of bottled water and 7,200 units of sachet water. That will give a sales revenue of 1.306,173.20. This solution is optimal because all the values at the Cj-Zj net evaluation now are negative and zero. The resources S_2 (raw material-water) and S_4 (space constraint) relating to sachet water have been exhausted. If more of these resources can be obtained, for example, water and storage space, the corporate outfit (company) will be able to produce more sachet water.

Summary of findings, conclusion and recommendations (remove)

Summary of Findings (the findings of the 4 objectives should reflect here)

The following findings became clear at the end of the study. Linear programming can be applied to any size of business establishment whether small or large. When applied it to Maxwell Table Water Company Limited, we obtained an optimal solution that required the production of 1,956.52 bottled water and 7,200 units of sachet water per week with sales revenue of #1,306,173.20. However, if more space and water can be acquired, this optimal solution can be improved upon. (this is more of recommendation) This is because what makes the solution above optimal is the fact that the raw material (water) was finished and the maximum quantity of bottled water that the store can take had been produced. The other two resources, namely space for battled water and man-hours have not been exhausted.

Conclusion

The linear programming model is useful for managerial decision-making strategy at every level. It is applicable to both large and small-scale business establishments. Although many assumptions are made, it is still a useful tool that can be relied upon as a guide to decision making.

As Peter Drucker (1981) puts it:
The manager will never be able to get all the facts he should have (to make a decision). Most decisions have to be based on incomplete knowledge – either because the information is not available or because it would cost too much in time and money to get it. To make a decision, it is not necessary to get all the facts; but is necessary to know what information is lacking in order to judge how much of a risk the decision involves as well as the degree of precision and rigidity that the proposed course of action affords …. when information is unobtainable.

This is what we have done in this paper. This paper has helped us to answer the research questions namely:

1. To what extent can linear programming be applied to Maxwell Table Water Company Limited? The response is that it can be applied to the extent that optimality in the use of scarce resources is possible; quantity to produce is precisely known and consequently profitability.
2. The raw materials used for their products are water, water tanks, polythene bags, water boiling machines and purifying substances.
3. The constraints of Maxwell Table Water Company Limited, Lokoja are:
   i. Man hours available
   ii. Amount of water available (material)
   iii. Space limitations
4. Prices of the products were given as:
   i. Bottled water 0.50 litre per bottle--#280 per carton of 12 bottles.
   ii. 0.75 litre bottle-----#350 per carton of 12 bottles.
   iii. 1.50 litre bottle-----#600 per carton of 12 bottles.
   iv. Sachet of water (0.6 litre)----#70 per bag of 12 bottles.

Recommendations

We have seen that Maxwell Table Water Company Limited has not been able to prepare a proper Statement of Accounts. This is imperative because it makes future research less cumbersome. Furthermore, the firm should acquire more storage spaces and even more water to meet the demands of the populace in Kogi State. A third tanker will increase the storage of raw material available for production. This will increase the Company's Sales revenue. Linear programming can be used to a good effect by large and small business outfits to ensure efficient utilization of scarce resources and by extension profitability.

REFERENCES

Akinsulire, O. 2006. *Financial Management*, (4th ed). Mushin Lagos: El-Toda Ventures Limited,.14 Bamgboye Street, Off LayiOyekanmi Street.
Butter, R. 1996. "Decision Making" in *International Encyclopediaof Business and Management,* Vol. 1, Malcolm Warner (ed.) Routledle, London.
Carlin T.W. 1970. *Business and The Man*, New York: Alexander Hamilton Institute.
Ewurum, U.J.F. 2016. Research Module on MAN 534, *Operations Research*, for the Degree of Master in Business Administration (MBA), 2016.
Ezigbo, C.A. 2007. *Advanced Course on Management, Theory and Application,* Enugu: Immaculate Publications Limited, 2 Aku Street, Ogui N/L.
Hornby, 2006. *Oxford Advanced Learners Dictionary* of Current English, 7th Edition, Oxford: University Press.
Kooz H. and Weihrich H. 2006. *Management, a Global Perspective*, 11th Edition, New Delhi: Tata McGraw-Hill.
Lapin, L.L. 1994. *Quantitative Methods for Business Decision with Cases*, (6th Ed), Fort Worth: the Dryden Press.
Lee S. M 1983. *Introduction to Management Science*, Chicago: The Dryden Press
Loomba, N.P. 1978. Management- *A Quantitative Perspective*, New York: Macmillan Publishing Co., Inc.

Minner, J.B 1973. *The Management Process: Theory, Research and Practice*, New York: The Macmillan Co.

Pearce II J.A and Robinson, Jr. R.B. 2003. *Strategic Management, Formulation, Implementation and Control*, Boston (8th Ed), International Edition, McGraw-Hill.

Peter Drucker 1981. *Toward the next economic and other essays*, London: William Heinemann Limited

Tulian P.C and Pandey V. 2002. *Quantitative Techniques, Theory and Problems,* Delhi: Pearson Practice Series.

Wilkes, M. 1989. *Operational Research*: Analysis and Applications, London: McGraw Hill Book Co.

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