

UNIVERSITY OF CAPE COAST

APPLICATION OF LINEAR PROGRAMMING IN PROFIT MAXIMIZATION OF
ASANDUFF CONSTRUCTION

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ASANDUFF CONSTRUCTION

BY

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A Project Work report presented to the Department of Mathematics, School of Physical Sciences, College of Agriculture and Natural Sciences of the University of Cape Coast, in partial fulfilment of the requirements for the award of Bachelor of Science degree in Mathematics

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DECLARATION

Candidate's Declaration

I, Clement Ampong Essandor, hereby declare that the Project Work is the result of my own research and that no portion of this Project Work has been submitted in part or whole for another degree in this University or elsewhere.

Candidate's Signature.....

Date

Clement Ampong Essandor

Supervisor's Declaration

I hereby declare that the preparation and presentation of the Project Work were supervised in accordance with the guidelines on supervision of Project Work laid down by the University of Cape Coast.

Supervisor's Signature.....

Date

Dr, Henry Amankwah

DEDICATION

I dedicate this work to my uncle, Mr, John Ampong, with the outmost love and gratitude.

ACKNOWLEDGEMENTS

I appreciate my supervisor, Dr, Henry Amankwah, for his guidance and encouragement, which enabled the creation of this report. His suggestions were incredibly beneficial to me. May God bless him.

I want to express my gratitude to the management and staff of Asanduff Construction for providing the information used in this study.

My deepest gratitude is extended to all my roommates and programme mates. Congratulations, guys.

ABSTRACT

An operation research method called linear programming is frequently used to identify solutions to managerial decision-making issues involving the allocation of limited resources in order to maximize profit and decrease cost. Practically, in all businesses and institutions, optimization has become a routine occurrence. The goal of this research was to apply linear programming for profit maximization in a block corporation. Asanduff Construction was used as our study case. Asanduff Construction manufactures four various sizes of building blocks (8 inches, 6 inches, 5 inches, and 4 inches). These sizes were taken into consideration in the study as the decision variables. The production cost, production time, demand or sales employed in the manufacturing, and the quantity of raw material needed for each block size were examined in order to determine the maximum profit using the linear programming technique. The problem was modeled, and solved with the use of excel solver software that used the simplex method to produce the best results. It was observed that three of the four types of building blocks account for the maximum profit of Asanduff Construction. The result shows that 800 unit of 8 inches block, 2200 unit of 6 inches block, 290 unit of 5 inches block, and 0 unit of 4 inches block should be produced respectively which will give a daily maximum profit of GHC 5564.00.

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CHAPTER ONE

INTRODUCTION

In this Project Work, we considered the application of linear programming in profit maximization. The data for this report was collected from Asanduff Construction and analysis of the data was carried out using excel solver.

1.1 Background to the Study

Linear programming (LP) is a very important technique that is adopted in the study of Operations research. Operations research refers to a method of decision-making that uses science to try to decide how to construct and run a system most effectively when there are limited resources (Oyekan, 2015). India is one of the few countries in the world to have implemented operation research. In fact, the Second World War may have been the first time that individuals realized that scarce resources could be distributed effectively (Anderson, Sweeny, & Williams, 1995). During World War II, British military commanders commissioned scientists to investigate military concerns such as radar deployment, bombing and mining operations. Dantzig (1949) coined the phrase “Linear Programming” in 1947 to describe specific optimization situations in which both the constraints and the objective functions are linear. The early uses of LP, like other fields of Operations Research, may be found in military planning operations. Not only in the military operations, but also in business and government, operation research has proven to be effective. Soon after that, LP became widely used in industry, with the food industry proving to be the most fruitful. Operation research is now employed in practically every field.

A mathematical technique for solving optimization problems is linear programming. It is also a popular Mathematical modelling tool for allocating limited resources to known activities with the purpose of achieving the desired goal (Taha, 1977). A Linear Programming problem is one in which the goal is to maximize the value of an objective function subject to certain constraints. These constraints are a collection of requirements that the optimal solution must meet. Any solution that satisfies the objective function and the set of constraints is referred to as an optimum solution. In LP, the objective function and the constraints are linear equations or linear inequalities. The goals of LP may be to reduce cost within the constraints of available resources or to maximize profit, which is the main purpose of this study. According to Akingbade (1996), the term “linear”, denotes proportionality, which means that the parts in a scenario are sufficiently related that when graphed, they look as straight line. While the “programming” denotes a way of problem solving that can be accomplished through an iterative process in which a researcher progresses from one solution to a better one until a final solution is obtained that cannot be improved upon. Mathematics, engineering, transportation, agriculture, military and economics are just a few of the domains where LP can be used. In addition to industry and business, nonprofit sectors including hospitals, libraries, and government can also benefit from Linear Programming. When driving or going from one location to another, we frequently use LP to find the shortest path or route. To describe the problem of concern, Linear Programming employs a mathematical model. As a result, we reduce a complicated set of real-world interactions or problems to basic linear relationships. As linear functions of the decision variable, the objective function and constraints can be defined. The

mathematical nature of LP makes it possible to answer important questions about the optimum solutions sensitivity to data changes.

The ultimate goal of every organization is to continue to exist and expand through time, hence profit making is the ultimate goal. This is because an organization's success or expansion depends on its ability to generate revenues on a consistent basis. Production of items at minimal cost and maximum profit that are of the proper standard, quantity and at the right time, especially for sustainability and growth, is the key to creating profits in manufacturing sectors (Oladejo, Abolarinwa, & Salawu, (2019)). As explained by Nonso (2005), the Board of Directors of a profit-seeking organization must deal with a variety of issues, including: the problem of other competitors in the same business, the availability of funds for new capital projects, the reduction of operational cost, high level of output and ultimately the maximization of profit.

Profitability in every organisation is determine by both operational and long-term business decisions. Every manager's primary responsibility is to make decisions about limited resources. These resources may include men, available raw materials, time, and money. It is the obligation of the management to make the best decision possible with these restricted resources in order to earn or maximize profit.

Nowadays, there has been a significant increase in the number of organizations or firms that may have been liquidated as a result of ineffective decision making. The issue is around determining which resources should be allocated in order to obtain the best profit and cost reduction. Considering the fact that different products demand different amount of production resources, a mathematical technique that can identify the appropriate quantity of resources to use in order to maximize profit is required. Managers utilize the Linear

Programming model, according to Wijeratne and Harris (1984), to find the most cost-effective financing arrangement, to schedule the optimal periods to start and end projects, and to select projects with the lowest total net percent cost of capital. Linear Programming is a commonly used mathematical technique for assisting managers with resource allocation planning and decisions-making, as well as providing relatively easy and realistic solutions to these problems (Bierman, Bonini, & Charles, (1973)). The economic literature recognizes the value of Linear Programming, particularly in developing countries with limited resources, where Linear Programming can assist in allocating these limited resources to get the best results.

This study illustrates the practical use of Linear programming techniques in a block manufacturing company to maximize profit, hence the objectives of Linear Programming could be to decrease cost within the constraints of available resources.

1.2 Statement of the Problem

Planning is a critical skill that is required on a variety of occasions in our daily activities, especially when resources are limited. The main objective of planning is usually to get a maximum profit or reduce cost when working with limited resources. One of the most significant aspects that people consider when starting a business is profit. This is because profit is what ensures a company's long-term survival and expansion. An organization will eventually collapse if the amount of resources invested is more costly than the profits it generates. Every organizations goal is to maximize profits while keeping low cost. That is, it is the manager's obligation to make the best decisions possible in order to maximize profit with the limited resource available. There has been a significant increase in the closure of numerous organizations throughout the years, which has resulted in an increase

in unemployment. Because of the high rate of unemployment among young people, social vices such as prostitution, armed robbery and drug addiction have increased. These organizations may have closed as a result of poor management decisions. As a result, businesses must design a manufacturing process in which certain production resources are assigned to produce the optimal number of units of each product. Again, most research work on Linear Programming in profit maximization focuses on larger or medium-sized businesses, while the local or small-scale businesses are left to rely on the trial-and-error method of production to reduce cost and maximize profits. To close this gap and give the owner of Asanduff Construction the power to make better decisions, it was necessary to demonstrate the validity of Linear Programming model in practice.

1.3 Purpose of the Study

The major goal of this study is to consider how organisations and businesses employ Linear Programming techniques to help them better manage their limited resources in order to maximize profits. We used the Asanduff Construction as a case study.

1.4 Objectives to the Study

The project sorts to meet the following objectives in other to reach the goal.

1. To formulate a Linear Programming model that ensures maximum profit of the company.
2. To learn about the financial and resources restrictions of the company.
3. To encourage businesses to use Linear Programming technique to maximize profit.
4. To draw attention of businesses that using Linear Programming technique to determine profit maximization would be more beneficial than doing it otherwise.

1.5 Significance of the Study

Investigating into the area of Linear Programming in profit maximization among organizations will be very beneficial in diverse ways. This project's entire motivation is to determine the best way to make decisions utilizing Linear Programming model in order to maximize profits while working with limited resources. Again, the study will provide a thorough understanding and insight into the uses of Linear Programming models in industries, as well as how to implement such models in real-world situations. Finally, findings of the study will serve as a reference material for future researchers or students with similar interest who may perform further research on Linear Programming techniques.

1.6 Organisation of the Study

This study is organised into five chapters. Chapter One presents the general introduction of the study, including background to the study, statement to the problem, purpose of the study, objectives to the study, significance of the study and the organisation of the study. Chapter Two entails literature from different researchers from different countries concerning the Recast. Chapter Three presents the research methodology of the study, collection of data, analysis of the data collected, and presentation of results. Chapter Four focuses on the discussion of the results. Chapter Five presents the summary, conclusions and also presents recommendations for the study.

1.7 Definition of Terms

In this section, we present some definitions that will be useful in this Project Work.

Binding Constraint: A constraint is binding if the left-hand side and the right-hand side of the constraint are equal when the optimal values of the decision variables are substituted into the constraint.

Nonbinding Constraint: A constraint is nonbinding if the left-hand side and the right-hand side of the constraint are unequal when the optimal values of the decision variables are substituted into the constraint.

Basic Solution: suppose that a linear programming is given in the standard form with n decision variables and m constraints, then a basic solution to the LP is where n of the variables are set to zero and the equation is solved for the other m variables. A basic solution exists if the solution is unique.

Basic Variable (BV): these are the variables whose value is obtained from the basic solution.

Non Basic Variable (NBV): these are variables whose values are assumed as zero in a basic solution.

Basic Feasible Solution (bfs): this is any basic solution to an LP in which all the variables are nonnegative.

Slack Variables: to change the linear constraints of a linear programming problem from inequality constraints to equality constraints, additional variables known as slack variables are added.

1.8 Chapter Summary

This chapter was focused on the introduction, background to the study, statement of the problem, purpose of the study and objectives of the study. Also, a short discussion was made on the significance of the study and how the work was organised. Again, basic terminologies that will be used in this Project Work were also presented.

CHAPTER TWO

REVIEW OF LITERATURE

2.0 Introduction

In agriculture, insurance, and many other sectors, but particularly in the business industries, Operational Research methodologies have been used to model and solve a wide range of problems. This Chapter seeks to provide relevant literature on Linear Programming, as well as its applications for maximizing profits in various organisations.

In the 1940s, the discipline of linear programming was born out of the need to discover answers for challenging planning issues during wartime activity. Most practical planning problems could be framed mathematically as finding a solution to a set of linear equations or inequalities, which made this achievable. Linear Programming technique is a mathematical device created by the mathematician George Dantzig in 1947 for organizing the many activities of the United State Air Force in relation to the problem of supply to the Force. Dantzig then proposed using this strategy to solve corporate and industrial difficulties. Dantzig also created the “simplex method”, a strong mathematical tool for solving linear programming problems (Dantzig, 1993). The method is now widely employed in all fields of management, including aviation, the healthcare system, agriculture, energy planning, and others. Managers who are familiar with Linear Programming rigorous models avoids its use since they do not know how it could be put to use. However, Taha (1997) adds other programming types in his contributions, such as integer, objective, quadratic, convex and stochastic. Taha claims that they are different in terms of the kind of data they can manage and assumptions they make. Finally, Taha shows

how the Ozark Poultry Farm used Linear Programming to establish the feed mix in order to maintain a balance ratio that includes calcium, protein, and fiber in the proper proportions. A step-by-step improvement strategy is used in an optimization model to identify the best option out of an infinite number of possibilities. An optimization algorithm outlines the procedures needed to get the optimal solution, which is what management is trying to do.

According to Dwivedi (2011), maximization of output, cost minimization, or resource allocation optimization is only one aspect of a firm's profit maximization, and that Linear Programming is useful in making business decisions because it aids in the measurement of complex economic relations and thus provides an optimal solution to the problem of resource allocation. Dwivedi claims that Linear Programming bridges the gap between abstracts economic theory and managerial decision-making. Dwivedi also emphasized the importance of having three specifications for any linear programming equation: objective function specification, constraint equation specification, and non-negative requirement.

Researchers at the Nigeria Bottling Company, Ilorin facility, employed the Linear Programming method to determine how to produce soft drinks with the greatest profit (Balogun, Jolayemi, & Akingbade, 2012). The corporation developed a linear operating program, and the simplex method was used to achieve the best results. Their findings demonstrated that more Coke 50cl and Fanta Orange 50cl should be produced in order to satisfy their customers, than producing Fanta Orange 50cl and 35cl, Fanta lemon, Sprite, and Schweppes. Additionally, as they typically add to the profit made, more Coke 50cl and Fanta Orange 50cl should be manufactured in order to maximize profit. In a similar study, to identify which bread size contributed most to profit maximization of the Johnsons

Nigerian limited bakery division, Oyekan and Temisan (2019) employed the simplex method of Linear Programming. The minimum and maximum cost coefficient of the bread size within which the business could maintain its ideal profit were determined by using sensitivity analysis.

Developing nations like Nigeria have increasingly caught up the trend of using Linear Programming in production planning. This is supported by research conducted by a number of academics, including studies by Kareem and Aderoba (2008) who determined the effectiveness of using Linear Programming model in maintenance and manpower planning using information gathered from a cocoa processing industry in Ondo State, Nigeria. Their research revealed that only four maintenance crew, out of a total of 19, are required to properly complete maintenance tasks in the industry, hence lowering the cost of labour for the cocoa producing company.

Ezema and Amakon (2012) also reported that the issue facing industries worldwide is caused by a lack of production inputs, which leads to low capacity utilization and therefore low outputs. In order to find and reach the ideal product-mix for the Golden Plastic Sector, they employed Linear Programming to profit optimization. The company was initially producing eight pipes, but data analysis and estimation show that only two sizes of the total eight polyvinyl chloride pipes should be produced. This was achieved by formulating the Linear Programming problem for the production of plastic and estimating as such. They also succeeded in determining that 7,136.564 pieces of 20 mm by 5.4 m thick pressure pipe and 114317 should be produced. In order to make a monthly profit of N1,964,537, two pieces of 25 mm by 5.4 m conduct pipe should be produced, along with zero quantities of the remaining size.

In a different study, Susilawati (2002) extended the use of linear programming to the development of dormitories at Petra Christian University in order to determine the number of rooms and area of each facility that could be accommodated while taking into account the restricted space of 4,994.83 square meters and a maximum cash flow of Rp 392,952.00 that is discounted by 17 percent per year for seven years. Using specialized computer software (excel solver) that can solve linear programming models, they were able to calculate the number of area of facilities such as restrooms, cafeterias, dining rooms, sport facilities, and bookshops. The outcome indicates that, aside from the garden, all supporting facilities must be improved.

Byrd and Moore (1978) used a study on an American manufacturing company to identify the ideal product-mix composition, and they viewed raw materials as a crucial restriction. Cost limitation take into account the highest cost that a company's production process can incur. They used linear programming to analyze the product-mix of 29 unidentified goods in their investigation. Under the constraints of capacity, demand, and the availability of raw materials, the goal is to maximize profit. As a result of the study, the management of the company proposed from focusing exclusively on high profit products for manufacturing, eliminating the low profit things from the list. Customers of the company were to be provided with a replacement product in its place.

Felix and Judith (2010) applied Linear Programming model to the distribution of farm resources. They compared the outcome from utilizing the Linear Programming model and the traditional approach of planning and found that the Linear programming model's results were significantly better than those from the traditional method.

According to Igwe, Onyenweaku, and Nwaru (2011), Linear Programming is a useful technique for improving the production planning efficiency, notably for boosting agricultural productivity. When they investigated how to maximize the gross return from semi-commercial agriculture in the Ohatia zone of Abia state, they came to this conclusion. The decision variable for general deterministic model are the number of hectares the farmer dedicated to the production of crop and the combination of crops or livestock capacity produced by the farmer. The general deterministic model is a gross margin maximization model designed to find the best solution.

Again, according to Stephans and Dimitrios (2010), when faced with a practical challenge of tremendous complexity, Linear Programming has given mankind the ability to state general goals and to lay out the path of precise decisions to take in order to “best” attain its aims. They contend that determining the relationships between an objective function, such as maximizing of profit for one or more items, is the first step in a straightforward Linear Programming activities.

In order to increase profit, Igbindehi, Oyebode, and Taofeek-Ibrahim (2015) used a Linear Programming model in a local soap manufacturer that makes three different types of soap: 5 g white soap, 10 g white soap and 10 g colored soap. The data study revealed that while the corporation spends more on colorful soap, they make more money from white soap. In order to maximize profits, the corporation was instructed to manufacture more white soap (5 g and 10 g) than colored soap.

In conclusion, it is required to further investigate and show examples of the usage of the linear programming model in business decision-making processes. A good possibility for such application is the determination of Asanduff Construction’s profit maximization.

This study will attempt to determine the characteristics of applying linear programming techniques to make management decisions and provide useful solutions to the issues.

2.1 Chapter Summary

This chapter discussed the relevant literature on linear programming. In order to maximize profit in a business and make better management decisions, nearly all studies agree that using linear programming method is preferable to doing it otherwise.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This Chapter describes the different approaches that can be used to solve a Linear Programming problem with focus on the approach that will be applied in this Project Work.

3.1 Research Methodology

A Linear Programming Problem (LPP) is a problem that is focused on finding the optimal value for a specific linear function subject to certain constraints. The optimal value may be either maximum or minimum value. The objective function is the function we are attempting to optimize, and the requirement that must be met are called the constraints. There are numerous ways to solve linear programming problem including the graphical method, simplex method, by using software like R, open solver, etc. The simplex method and the graphical method are the two key methods that are commonly used in solving linear programming problem.

The graphical method is used to optimize the value of two-variable linear problems. Finding the optimal solution is best done using the graphical method when there are only two decision variables. The collection of linear equations or inequalities are subject to constraints in this method. These linear equations or inequalities are then plotted in the X-Y plane. The intersection region will be used to determine the feasible region once all the linear equations or inequalities have been drawn on the X-Y graph. The optimal solution and all possible values for our model are explain by the feasible region. The feasible region for a Linear Programming is the set of all points that satisfies all the LP's constraints and

all the LP's sign restrictions. However, the graphical method is limited to problems with only two decision variables. It gets more difficult to visualize the solution space as the number of decision variables and constraints increases. Because of this, it is impossible to successfully use the graphical technique in such circumstances. To overcome this limitation, George Dantzig developed the simplex method, which was already discussed in Chapter Two and is a useful approach for solving Linear Programming Problems. The simplex method can be used to solve problems involving two or more decision variables.

To solve a Linear Programming Problem using the simplex method, the following steps must be followed.

1. Identify and set up the problem. Thus, write the objective function and the inequality constraints to set up the problem.
2. Convert the problem into its standard form. To do this, each "inequality sign" (\leq or \geq) in the constraint is changed into an "equal to sign" ($=$) by adding slack variables or subtracting excess variables respectively.
3. Set up the initial simplex tableau by using the standard form of LP.
4. Determine the optimal tableau by performing pivoting operations.
5. From the optimal tableau, identify the optimal solution.

Through an iterative procedure, the simplex method eventually reaches the minimum or maximum optimal value for the objective function. In solving a linear programming problem, one of the following four solutions is achieved:

1. Unique solution. This solution satisfies all the LP's constraints with minimum or maximum objective function value.

2. Some LP's have infinite number of solutions. This means that the LP has multiple optimal solutions.
3. Infeasible solution. This means that the LP contains an empty feasible region and hence no optimal solution exists.
4. Some LP's are unbounded. They are points in the feasible region with arbitrary large objective function value.

3.2 Linear Programming Model

Linear Programming models are used to represent Linear Programming problems mathematically. There are three component to a Linear Programming problem. The first is that an objective function exists and the objective function can be either maximized or minimized. The second is a set of linear constraints that describes the technical details of the issues in respect to the available resources. The third is that while negative or zero production does not have a physical counterpart, there are a number of non-negative limitations or restrictions. In general, any Linear Programming model with decision variables for a maximization problem can be expressed in the form;

$$\text{Maximize } Z = A_1X_1 + A_2X_2 + \dots + A_nX_n \quad (\text{Objective function})$$

Subject to

$$C_{11}X_1 + C_{12}X_2 + \dots + C_{1n}X_n \leq B_1$$

$$C_{21}X_1 + C_{22}X_2 + \dots + C_{2n}X_n \leq B_2$$

$$C_{31}X_1 + C_{32}X_2 + \dots + C_{3n}X_n \leq B_3$$

$$\dots \quad \dots \quad \dots \quad \dots \quad \dots$$

$$C_{m1}X_1 + C_{m2}X_2 + \dots + C_{mn}X_n \leq B_m \quad (\text{Linear constraints})$$

$$X_1, X_2, \dots, X_n \geq 0. \quad (\text{Sign restriction}).$$

Here,

Z is the total profit contribution. X_i represents the decision variables and it shows the number of each type of blocks needed to be produced (for $i = 1, 2, \dots, n$). A_i represents the profit for each unit of product i . B_j shows the total amount or number of available resources j (for $j = 1, 2, \dots, m$). C_{ij} represents the amount of resource j that is used by each unit product i . Similarly, the $X_i \geq 0$ shows the non-negative restrictions or conditions.

There are various characteristics that set Linear Programming models apart. We can recognize problems that can be solved with LP models and properly construct an LP model by being aware of these characteristics. These characteristics can be separated into components and assumptions. A model's components relates to its structure, whereas assumptions provide the conditions under which a model is valid. The above-mentioned model must abide by the following assumptions in order to be considered valid.

1. It is considered that the amount of raw materials needed for the block production is finite (limited).
2. It is assumed that the characteristics of the components used to produce block are standard and not inferior.
3. It is assumed that the variables used in the model have a linear connection.
4. The quantity of blocks produced is presumed to be equal to the quantity of blocks sold.

Since producing goods that are not in demand is impractical.

3.3 Data Collection

Data for this work was collected from Asanduff Construction. Asanduff Construction is a company that manufactures high-quality building blocks to meet the need of its customers. An interview was conducted with the administration officer of Asanduff Construction specifically to learn more about the decision-making process used by the company. Through the interview, it was observed that, four (4) different types of blocks (8 inches, 6 inches, 5 inches and 4 inches block) are produced by Asanduff Construction. The block production machine creates four (4) blocks on a palette for 8 inches, six (6) blocks on a palette for 6 inches, eight (8) blocks on a palette for 5 inches, and twelve (12) blocks on a palette for 4 inches.

Again, data was gathered on the unit cost of production for each type of block, the unit selling price of each type of block, the average daily cost price for producing all four types of block, and the daily working hour that is available for both human laborers and the block machines. Additionally, information on the blocks with the highest daily sales was gathered. Table 1 to Table 4 provide a summary of the information gathered.

Table 1: Requirement for each block type

Block type	Machine hour (s)	Labor hour (s)	Average production cost (GHC)
8 inches	0.32	0.41	30
6 inches	0.45	0.55	32
5 inches	0.53	1.15	40
4 inches	1.03	1.90	50

Table 2: Available resources

Resource	Available
Machine hour	32400
Labor hour	32400
Production cost (GHC)	106,000

Table 3: Production and profit for each block type

Block type	Unit cost price (GHC)	Unit selling price (GHC)	Unit profit (GHC)	Daily Demands
8 inches	7.50	9.50	2.00	800
6 inches	5.33	7.00	1.67	2200
5 inches	5.00	6.00	1.00	3300
4 inches	4.20	4.70	0.50	350

Table 4: Summary of Table 1 to table 3

Block type	Machine hour	Labour hour	Average production cost (GHC)	Daily Demands	Profits (GHC)
8 inches	0.41	0.32	30	800	2.00
6 inches	0.55	0.45	32	2200	1.67
5 inches	1.15	0.53	40	3300	1.00

4 inches	1.90	1.03	50	350	0.50
Available	32400	32400	106,000		

3.4 Analysis of the Data

The number of decision variables for each type of block to be manufactured in the block company is specified as follows.

X_1 represent the number of 8 inches blocks to be produced daily

X_2 represent the number of 6 inches blocks to be produced daily

X_3 represent the number of 5 inches blocks to be produced daily

X_4 represent the number of 4 inches blocks to be produced daily.

Again, let the objective function which is to be maximize be denoted by Z . Then, the mathematical representation of the above problem (data) summarized in Table (4) is given as follows.

$$\text{Max } Z = 2.00X_1 + 1.67X_2 + 1.00X_3 + 0.50X_4 \quad (\text{objective function})$$

Subject to

$$0.41X_1 + 0.55X_2 + 1.15X_3 + 1.90X_4 \leq 32400 \quad (\text{machine constraint})$$

$$0.32X_1 + 0.55X_2 + 0.53X_3 + 1.03X_4 \leq 32400 \quad (\text{labour constraint})$$

$$30.0X_1 + 32.0X_2 + 40.0X_3 + 50.0X_4 \leq 106000 \quad (\text{cost constraint})$$

$$X_1 \leq 800 \quad (8 \text{ inches block constraint})$$

$$X_2 \leq 2200 \quad (6 \text{ inches block constraint})$$

$$X_3 \leq 3300 \quad (5 \text{ inches block constraint})$$

$$X_4 \leq 350 \quad (4 \text{ inches block constraint})$$

$$X_1, X_2, X_3, X_4 \geq 0. \quad (\text{Non-negative restrictions})$$

The problem is converted to the standard form by adding seven slack variables, denoted by S_i ($i = 1, 2, 3, 4, 5, 6, 7$). As a results, the inequality signs in the model's constraints aspect were changed to equality signs. A slack variable will take into account any unused raw material at the end of the production process. The standard form of the problem is given below.

$$\text{Max } Z = 2X_1 + 1.67X_2 + X_3 + 0.50X_4 \quad || \quad Z - 2X_1 - 1.67X_3 - X_3 - 0.50X_4 = 0$$

Subject to

$$0.41X_1 + 0.55X_2 + 1.15X_3 + 1.90X_4 + S_1 = 32400$$

$$0.32X_1 + 0.55X_1 + 0.53X_3 + 1.03X_4 + S_2 = 32400$$

$$30.0X_1 + 32.0X_2 + 40.0X_3 + 50.0X_4 + S_3 = 106000$$

$$X_1 + S_4 = 800$$

$$X_2 + S_5 = 2200$$

$$X_3 + S_6 = 3300$$

$$X_4 + S_7 = 350$$

$$X_1, X_2, X_3, X_4, S_1, S_2, S_3, S_4, S_5, S_6, S_7 \geq 0. \quad (\text{Non-negative restrictions})$$

Excel's built-in solver was used to solve the Linear Programming model mentioned above. Excel solver is a software that assists users in choosing the optimal solution to a Linear Programming problem. The decision variable values that satisfy the constraints while maximizing the profit will be discovered using the excel solver. Excel solver offers useful information, like sensitivity analysis, answer report and limit report. The models decision variables, objective function and the constraints are placed in the appropriate spreadsheet cells with numbers that the solver can used. In Figure 1 below, the worksheet's cells C2, D2, E2, and F2 are held in reserve for the decision variables X_1 , X_2 , X_3 , and X_4 . These cells will determine the number of each type of block to be created.

Figure 1: Presentation of the data in excel worksheet

	A	B	C	D	E	F	G	H	I	J	K	L
1	decision variable		x1	x2	x3	x4						
2	value of		0	0	0	0						
3	objective function		2	1.67	1	0.5						
4												
5	profits											
6		0										
7							LHS		RHS			
8	machine constraint		0.52	1.33	1.52	2.5	0 ≤		32400			
9	labour constraint		0.32	0.45	0.53	1.05	0 ≤		32400			
10	cost constraint		30	32	40	50	0 ≤		106000			
11	8 inches block constraint		1				0 ≤		800			
12	6 inches block constraint			1			0 ≤		2200			
13	5 inches block constraint				1		0 ≤		3300			
14	4 inches block constraint					1	0 ≤		350			
15												
16												
17	Non-negative restriction		1				0 ≥		0			
18	Non-negative restriction			1			0 ≥		0			
19	Non-negative restriction				1		0 ≥		0			
20	Non-negative restriction					1	0 ≥		0			
21												
22												

The profits being maximize is entered in cell A5 and its value is entered in cell A6. The formula for finding the profit in cell A6 is given as.

Formula for cell A6: =SUMPRODUCT(C2:F2,C3:F3)

The available resources needed to produce each unit of block is entered in cell C8:F14. These numbers are the coefficients of the decision variable in the model's constraints equation. Again, the sign restriction constraints are entered in cell C17:F20. The data were analyzed using excel solver and the solution is presented in Figure 2.

Figure 2: Solution of simplex method from excel worksheet

	A	B	C	D	E	F	G	H	I	J	K	L
1	decision variable		x1	x2	x3	x4						
2	value of		800	2200	290	0						
3	objective function		2	1.67	1	0.5						
4												
5	profits											
6	5564											
7							LHS		RHS			
8	machine constraint		0.52	1.33	1.52	2.5	3782.8	≤	32400			
9	labour constraint		0.32	0.45	0.53	1.05	1399.7	≤	32400			
10	cost constraint		30	32	40	50	106000	≤	106000			
11	8 inches block constraint		1				800	≤	800			
12	6 inches block constraint			1			2200	≤	2200			
13	5 inches block constraint				1		290	≤	3300			
14	4 inches block constraint					1	0	≤	350			
15												
16												
17	Non-negative restriction		1				800	≥	0			
18	Non-negative restriction			1			2200	≥	0			
19	Non-negative restriction				1		290	≥	0			
20	Non-negative restriction					1	0	≥	0			
21												
22												

3.5 Presentation of Results

The optimal results obtained from excel solver is presented in Table 5.

Table 5: Optimal solution

Objective Name	Value
Profits	5564

Table 5: Optimal solution

Variable Name	Value
value of x1	800
value of x2	2200
value of x3	290
value of x4	0

From Table 5, it can be observe that the optimal solution for the model is, $X_1 = 800$, $X_2 = 2200$, $X_3 = 290$, $X_4 = 0$, and the profits being maximizes $Z = \text{GHC } 5564.00$.

3.6 Shadow price

The shadow price of the i^{th} constraint shows the amount by which the optimal Z- value is improved (increased in a maximization problem and decreased in a minimization problem) if we increased b_i by one unit. The shadow price of each constraints is presented in Table 6.

Table 6: Shadow Price Result

	Shadow
Name	Price
machine constraint	0
labour constraint	0
cost constraint	0.025

8 inches block constraint	1.25
6 inches block constraint	0.87
5 inches block constraint	0
4 inches block constraint	0

3.7 Chapter Summary

The methodology of the work was the main topic of this Chapter. The graphical method, the simplex method, and excel solver were the methods discussed in this Chapter. The simplex method is preferred for solving linear programming problems over the graphical method because the simplex method is not restricted by any number of available constraints. Data was collected from Asanduff Construction and analysis was carried out on the data using excel solver. The results of the data together with the shadow price were also presented.

CHAPTER FOUR

DATA ANALYSIS

4.0 Introduction

In this chapter, we take into account the outcome of the optimal solution for the data examined in Chapter Three and explain the findings.

4.1 Discussion of Results

Based on the analysis carried out in this project, the result shown in Table (5) require that Asanduff Construction should produce daily, 800 pieces of 8 inches block, 2200 pieces of 6 inches block, 290 pieces of 5 inches block and no pieces of 4 inches block should be produced. This production strategy would results in a daily profit of GHC 5564.00 for Asanduff Construction. These show that just three of the four types of block account for the maximum profit. Therefore, the 8 inches block, 6 inches block, and 5 inches block are the best products the company can sell for the highest profit. In this situation, it is preferable for Asanduff Construction to concentrate on lowering resources costs on producing the 4 inches block, since it does not add much to their profits.

Again, from Table (6), the shadow price of the machine constraint, the labour constraint, the 5 inches block constraint, and the 4 inches block constraint are all zero (0) respectively. This means that increasing the amount of these constraints by one unit would not result in an increase in Asanduff Construction's profit. Also, the shadow price of the cost constraint is 0.025. This means that increasing the amount of the cost constraints by one unit would result in an increase in Asanduff Construction's profit by GHC 0.025. The shadow price of the 8 inches block constraint is 1.25. This means that increasing the amount of the 8 inches

block constraint by one unit would result in an increase in Asanduff Construction's profit by GHC 1.25. Lastly, the shadow price of the 6 inches block constraint is 0.87. This means that increasing the amount of the 6 inches block constraint by one unit would result in an increase in Asanduff Construction's profit by GHC 0.87.

4.2 Chapter Summary

From the analysis of the results obtained, it was observed that three of the four types of building blocks account for the maximum profit of Asanduff Construction. The results showed that, with a daily production of 2200 blocks, the 6 inch block generated the highest profits, followed by the 8 inch block with a daily production of 800 blocks, and the 5 inch block generated the least profits with a daily production of 290 blocks. The shadow price of the data were also covered and it was noted that increasing the constraints of the cost constraint, the 8 inches block constraint, and the 6 inches block constraint accounts for an increase in profit, however the remaining constraints do not account for an increase in profit for Asanduff Construction.

CHAPTER FIVE

CONCLUSION

5.0 Overview

Applications of Linear Programming in Profit Maximization of Asanduff Construction is the topic of this research work. The major goal of this study is to consider how organisations and businesses employ Linear Programming techniques to help them better manage their limited resources in order to maximize profits. Asanduff Construction is a company that manufactures high-quality building blocks to meet the need of its customers. Asanduff Construction manufactures four various sizes of building blocks (8 inches, 6 inches, 5 inches, and 4 inches). Data was collected from the company and analysis was performed using excel solver software that used the simplex method to produce the best results. According to the findings, three of the four different block sizes (8 inches, 6 inches, and 5 inches) produced income whereas the fourth one did not add any income. Since the 4 inches block does not significantly increase Asanduff Construction's profit, it is preferable for them to focus on reducing resource costs for producing it.

5.1 Summary

The goal of this research was to apply linear programming for profit maximization in a block corporation. Asanduff Construction was used as our study case. Asanduff Construction manufactures four various sizes of building blocks (8 inches, 6 inches, 5 inches, and 4 inches). These sizes were taken into consideration in the study as the decision variables. The production cost, production time, demand or sales employed in the manufacturing, and the quantity of raw material needed for each block size were examined

in order to determine the maximum profit using the linear programming technique. The problem was modeled, and solved with the use of excel solver software that used the simplex method to produce the best results. The result shows that 800 unit of 8 inches block, 2200 unit of 6 inches block, 290 unit of 5 inches block, and 0 unit of 4 inches block should be produced respectively which will give a daily maximum profit of GHC 5564.00.

5.2 Conclusions

We successfully took into account the various product categories, the quantity of raw materials used, and the cost of manufacturing in Asanduff Construction in this study. The best solution was discovered after formulating the linear programming problem using secondary data on the four types of building block sizes that were collected from the company's administrative department. The outcome showed that, in order to achieve a maximum daily profit of GHC 5564.00, the management of Asanduff Construction should concentrate more on the manufacturing of the 8 inches, 6 inches, and 5 inches building block size. The primary objectives of the study are to highlight the distinctiveness of linear programming modeling as an optimization technique at the business level and to persuade manufacturing organizations to use linear programming to calculate their ideal profit. These observations will enable the block factory to maximize its contribution both now and in the future with these production techniques.

5.3 Recommendations

All production planning challenges can be solved by linear programming models, which increase production capacities, reduce costs, and ultimately increases profits for production industries and businesses.

It is recommended that Asanduff Construction employ the linear programming method in their operations. This is due to the linear programming method's ability to determine the proper number of which products to manufacture more and which ones to manufacture less with their limited resources.

Additionally, it is recommended for Asanduff Construction to concentrate on lowering resources costs on producing the 4 inches block, since it does not add much to their profits and focus more on producing the required amount of the remaining block sizes.

The findings of the research suggest that in order to boost profitability, production companies should begin utilising mathematical techniques like linear programming. Managements are advised to spend more money on mathematics consultants.

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