BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF MATHEMATICS AND PHYSICS

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OPTIMIZATION OF THE OPERATIONAL COSTS IN THE PRODUCTION ,SUPPLY AND DEMAND OF BREAD AND CONFECTIONARIES (BAKERS INN)

BY

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APPROVAL FORM

I Privilege Chakuwamba do hereby declare that this submission is my own work apart from the references of other people's work, which has duly been acknowledged. I hereby declare that this work has been presented neither in whole nor in part for any degree at this university or elsewhere.

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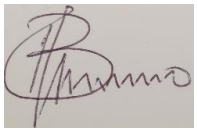
MR. B KUSOTERA …  ……

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DEDICATION

……To my loving mother.

ACKNOWLEDGEMENTS.

My reverence and honor goes to the Lord Almighty for keeping me healthy and giving me strength throughout these studies.

My gratitude at large goes to my mother Ms D. Chakuwamba, my guardian Mr N. Mushayanembwa , my pastors Mr B.I. and Mrs H.V. Shonhiwa and my friend Patricia Mapimbiro not foregoing my colleagues who have been the greatest encouragers and helping hands during the whole period, giving me unwavering support academically, spiritually and motivation.

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ABSTRACT

The research study was focused on minimization of transportation costs of supplying bread from 2 major bakers inn bakeries to different destinations in Zimbabwe .Optimization is a process that helps businesses to improve their efficiency ,increase their productivity and enhance their performance.It can assist businesses with their internal and external operations depending on their inique needs. A business may use analytics that is information or data gathered from statistical research to help them make decisions. The objectives were to determine product mix that minimize costs and optimal routes for transportation. To meet these objectives both primary and secondary data were used. Secondary data obtained from the finance archives was significantly used in the Excel solver. According to the EXCEL SOLVER results, SENSITIVITY ANALYSIS is the best report to employ for maximum or minimization solutions to optimization issues. The study's solution makes it abundantly clear that the business should take into account the two main factories to supply at the nearby regions in order to reduce costs, such as those incurred by the Harare factory to Southern regions, which includes Matebeleland Province even though there is a factory there as well. However, the factory in Bulawayo should think about increasing output to meet demand in the areas that Harare formerly served, and Harare should also consider reducing production and concentrating on adjacent areas. According to the findings, Harare's supply was in excess of demand, which might also lead to waste a loss.

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ACRONYMS

MODI	MODIFIED DISTRIBUTION METHOD
B.I	BAKERS INN
LLP	LINEAR LOGIC PROGRAMMING
NW	NORTH WEST
LCM	LEAST COST METHOD
SST	STEPPING STONE TESTING

Chapter 1

1.1 Introduction

In recent days production and consumption have swiftly grown therefore, companies and manufacturers are trying to find cost reduction aimed at ensuring competitiveness. The supply chain expenses play a critical role in the cost on the final products in manufacturing companies. This research will focus on the impact of costs in the production ,supply and demand of bread and confectionaries with a case of Bakers Inn (B.I) Company.

This chapter will cover the background of the study, problem statement and objectives for the research. It will also highlight the research questions and significance of the study. The chapter will also provide the delimitations and limitations encountered in the course of the study, a summary of the chapter and an account of the research design and the definition of terms.

1.2 Background of the Study

There is an increase in manufacturing costs and a depreciation in sales revenue obtained which led to the decrease in profit maximisation by the manufacturers. This has perplexed and pushed the researcher to address the growing problem through this research paper. A lot of manufacturers and businesses are facing difficulties in increasing their sales volumes and profitability because of different factors, (Mahakam, 2014).The factors include a countable number of companies are having an increase in sales volumes and market share in economies where consumers have very low disposable incomes. This reduction in growth prospects are going along with an increased cost. Mapakume (2014) affirmed that operational cost and production cost are very high in economies where consumers have very low disposable incomes. High cost in production and a decrease in sales volumes has led to a decreased profitability in these manufacturing companies. Due to very limited sales growth prospects, industries have to concentrate on cost which is a key element in profitability level. Reduction in costs and controlling them is very important in a company because this increases the company's profitability.

In a study carried out by Bloch (2014) showcase how the manufacturing sector has deteriorated, downsizing the levels of production and ceasing operations. This has been traced back to the

hyperinflation experienced in 2008 by the country which led to very low investments, increased costs of production and a sharp decrease in disposable incomes of the consumers. Bloch (2014) postulates that even though the dollarization curb inflation, a surge in salaries and wages contributed to an increase in materials and other costs in manufacturing industries. Bloch (2014) adds that profitability, operations and performance are negatively affected by an increase in cost.

According to Kachembere (2015) the output produced by Zimbabwean manufacturing industries in 2014 negatively contracted by 4.9%. The Central Bank of Zimbabwe's economic report showcase that there was an immense decline in the manufacturing outputs, Kachembere (2015). This was due to factors such as high costs of production, pathetic effective demands, out-dated machinery and the influx of cheap goods. During this period of time a lot of companies shutdown and there was liquidation because of high cost in production that greatly affected the profits and revenues of a lot of manufacturing companies. Statistics that were gathered from Master of High Court revealed that in 2013 there were fifty-one companies under judicial management and the number rose in 2014 to sixty, and in 2013 only forty-four companies were liquidated as compared to eighty-seven companies.

During this period Delta Beverages, a manufacturing company of alcoholic and non-alcoholic beverages recorded a 10 % decrease in revenue collected from March to December 2014. Declining in revenue for Delta Beverages continued falling since 2014 and in the financial results of the period ended April to

September 2016, the company's revenue declined by 80%. This has a very huge negative impact on the profitability of Delta Beverages, (Mhlanga, 2017).

According to Mhlanga (2017) the shortage of foreign currency in Zimbabwe, declining in industries competitiveness, pressure on costs and depressed demand worsened the operating environment of the industries in the country. This led to the companied failed to fully perform and continue on mass productions. According to Mhlanga (2017) due to this economy which was struggling a lot of companied failed to notice sales increase and those few that were sustaining, their sales were increasing at a diminishing rate. There was an evidence of declining in the capacity utilisation from 47.4% in the year 2016 to 45, 1 % in the year 2017, (Mazambani, 2017). Therefore, according to Mazambani (2017) for companies to increase their profitability and capacity,

Zimbabwe's costs structure should be addressed because costs greatly affect the final product cost and capacity utilisation. Cost control measures in supply and demand should be implemented so as to regulate costs and improve profitability.

In a study conducted by Siyanbola and Raji (2013) on West African Cement Company, West Africa, they considered budget as the key tool in achieving operational cost control. In their study on the impact of cost in supply and demand, Siyanbola and Raji (2013) noted that cost control is very crucial in every company and business for its profitability. The negligence of it will negatively affect the company's earnings at any time. Effective cost control eliminate wastage during production, administration, distribution of activities and selling.

In a research carried out by Akeem (2017) in Nigeria on the impact of cost in supply and demand shows that there is a close relationship between cost control, supply, demand, reduction and profit. The study exposed that there is need to reduce and control cost and increasing the supply so as to ensure that the organisation increase its profit growth.

1.3 Problem Statement

Due to increasing globalisation, manufacturers should be more competitive in order to withstand in the market. For the manufacturers to stay competitive, they should provide an understandable price of the product. There is an increase in the production cost which is then affecting the product cost, supply and demand. This has also negatively affected profitability on manufacturing companies. This research intents to address these problems.

1.4 Research Objectives

The research seeks to:

i. Determine product mix that minimize production costs

ii. Determine optimal transportation routes that minimize transportation costs

1.5 Research Questions

i. What Bakers Inn's objective of operational cost in production, supply and demand of bread and confectionaries?

ii. What are the requirements needed to ensure an effective operational cost to improve on profitability at Bakers Inn?

iii. What are the operational cost techniques used by Bakers Inn in ensuring production, supply and demand of bread and confectionaries.

1.6 Significance of the Study

This study will help the management of various companies in the manufacturing sector so as to have a reflection on the problems of cost in supply and demand. The research will shade more light the impacts of cost reduction measures on profitability. This will help organisational officials to understand the impact of implementing weak cost reduction methods. The research will help the researcher to have a deep understanding and knowledge of cost reduction systems employed by different companies. The study will also help in showcasing the requirements needed to ensure an effective operational cost to improve on profitability in production companies. In addition, that the study was of great importance to scholars and researchers, the findings of the study would contribute information and knowledge to the existing literature about operational costs in the production, supply and demand of products to customers.

1.7 Assumptions

The researcher assumed that information provided is free from bias and Bakers Inn's responses represents other manufacturing companies in bread and confectionary manufacturing. The researcher also assumed that selected participants has a great understanding of the subject matter.

1.8 Limitations of the study

Some respondents were unwilling to cooperate or respond due to work pressure or confidentiality reasons. The researcher focused on major areas concerning the research so as to save respondent's time. Some information desired was not released as such information deemed highly confidential

to the company. Clarification was made on the use of information that is, information required was used for academic research.

1.9 Delimitations of the study

The research was conducted in Harare. The targeted population of this study include Bakers Inn employees. This study was limited to operational control in manufacturing industries and as such it does not extend to other sectors of the economy. Participants drawn from Bakers Inn departments include finance, human resource, production and processing, sales and marketing and quality control.

1.10 Definition of terms

Production

Production is an act of manufacturing, making and producing products so that they can be used.

Cost

It can be defined as the monetary value that a company has spent in order to produce a unit.

Cost control

Akeem (2017) defined cost control as a process of averting wasteful use of valuable resources and encouraging efficiency and cost consciousness.

Supply

This is an act of making products available to customers for use.

Demand

This is defined as the desire to purchase goods and services.

Profitability

It can be defined as the excess of revenue and cost.

1.11 Summary

This chapter offers an overview of the background of the study, the problem statement, research objectives and the research questions. It also looked at the importance of the study. The next chapter presents a review of the literature.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter briefly discusses the theoretical and empirical literature enlign with the profit generated from the bakery industries compared to the costs incurred in producing and supplying bread and confectionaries to different retail centres .It centres on facts of divergence and convergence amongst many writer and as well contains the writer personal ideas with citation to sources of production and retail disparity within the sector .It is also likely to assist the researcher to identify the factors influencing demand and supply and the importance of minimizing production cost and maximize profits.

2.2Theoretical framework

(K. Wang 2011.)Mathematical optimization is the process of minimizing and maximizing an objective function by finding the best available values across a set of inputs. A number of techniques can be used and chosen for solving optimization problems but all optimization problems require a minimum of an objective function to express the output that is being minimized or maximized. The function can be with specific effects or can achieve a probability threshold.

(Nikolas Hansen 2005) states that different kinds optimization algorithms have been designed and applied to solve real –parameter function optimization problems. Optimization is the process of modifying the inputs or characteristic of a device, mathematical process to max, imize and minimize outputs. The input to the optimization process is the cost function, fitness function or the objective function and the fitness function of the process is the output (Sinha B. P. 2003)

(Krohling R.A. and Rey J.P. 2001) defines optimization as a primary tool , needed to solve unsolvable or difficult problems. It is categorized into five algorithms including trial and error optimization , dynamic optimization , discrete variable optimization ,constrained optimization

and one dimensional optimization. (Andreas Antoniou 2021) constrained optimization provides a general framework in which a variety of design criteria and specifications can be readily imposed on the required solution. (Kenneth Lange 2018) expresses one dimensional optimization problems occur throughout mathematical sciences and most of these problems cannot be solved analytically. (John Wiley and Sons 2019) Optimization is act of obtaining the best result under given circumstances. The ultimate goal of all such decisions is either to minimize the effort required or to maximize the desired benefit. It can be defined as the process of finding the conditions that give the minimum or maximum value of the function.

2.3Theoretical review

Studying the production and manufacturing costs is empowered by reviewing several supporting theories in the area of baking industries .The logistics function has always been shared responsibility between procurement and marketing department .It is the key component of supply chain management process that involves the planning ,organising and controlling the movement of goods and services from the point of production to the point of consumption (Cooper and Hartley 2014). This study will focus on 4 theories, LLP linear programming, LLP Transportation theory(Charles Horton),Game theory and Simulation.

2.4 Theories of production costs

2.4.1 LPP: Linear Programming

Linear Programming is the method of choosing the best (optimal) alternative amongst the available (feasible) alternatives for either profit maximization or cost minimization, when the objective function and the constraints are mathematically expressed. Firms and other organizations face constraints in achieving their goal of profit maximization, cost minimization and other objective .L.V Kantorovich 1939 developed the linear programming technique to solve constrained maximization and minimization problems. George Dantzing 1947 extended it as a branch of mathematical programming designed to solve optimization problems where objectives and all the constraints involved can be expressed as a linear function, therefore it was developed for finding optimal solutions to problems of supplies.

It is a powerful tool for decision making under certainty as well as it can be used to verifiy and check mechanism to ascertain accuracy and the reliability of the decisions which are taken solely on the basis of manager's experience without the aid of the mathematical model. According to Dantzing the theory helps in maximization of resources that are limited in nature.

2.4.2 LPP: Transportation

Distribution models help to determine the efficient transportation routes for moving the goods from factory / plants to different warehouses. The growth of transportation provides a medium, contributing to the progress of agriculture, industry, commerce, administration, defence, education, health or any other community activity. White and Senior (1983), considered five basic factors, which contribute to the growth and development of transport systems and the ways in which changes take place.

E.U.L Imaga (2007) asserts that the transportation model relies on the idea of transplantation, such as moving a product unchanged from one location to another. First, it makes the assumption that any attempt to sabotage or alter the concept in transit will somehow weaken and harm it. It also presupposes that it is possible to transfer an idea from one person's mind into another, leading to identical understanding between the two. The transportation model is a useful tool for

examining and changing current transportation systems or putting new ones into place. The concept works well for allocating resources in current business models. The source of the supply, the final destination of the supply, and the cost per unit of the supply are three important pieces of data that the model needs.

In order to correctly balance cost and supply, business decision-makers might utilize the transportation model as a comparing tool. By calculating a minimal cost for shipping from various sources to various destinations, this model will assist in establishing what the best shipping strategy is. This will make it easier to compare alternatives when determining how they would affect a system's overall cost. Location decisions are the primary uses of the transportation model discussed in this study.(Handy 1993) assumes that in the model 1) Items are homogenous 2) Transporting costs per unit are the same no matter how many units are to be delivered. 3) Only one route is used from place of production to the destination.

In solving a transportation problem, the programmer is required to identify the variables in the solution. There must be an existence of ,a clear isolation of the objective function and the structural constraints. Mahmud (2017) developed systematic steps in transportation scheduling,

i) **Setting up the initial transportation table**

This involves the setting up of the columns and rows with identification symbols and assumed inventory delivery costs per unit. Source capacities are identified horizontally while destination requirements are identified vertically that is rows and columns respectively. At this stage, all the existing cells are unoccupied(empty). All inventories emanating from all sources and being absorbed in all demand points are added up separately for a balance. A dummy cell earlier emphasized could be created here to rectify an imbalance if the situation arose.

ii). **Developing an Initial Basic Feasible Solution**

Two conventional approaches that are utilized here are the North-West(NW) corner rule and the least cost method. Using the NW Corner Rule here the inventory allocation to cells begins from the top left hand corner (northeast). Maximum allocation is made subject to source and destination constraints. A corollary condition exists here: The edge requirement of each column

must be satisfied before moving to the next column (right direction). The source capacity of each row must be satisfied before moving to the next row (downwards). When all edges' capacities and requirements have been met, the total cost is obtained. For a solution to be basic feasible the number of (cells with inventory allocations) must be equal to the total number of rows and columns (say m and n) less one, i.e. number of occupied cells = (m+n)-1.

The Least Cost Method's(LCM) emphasis here is on making the first allocation to the cell that has the least transportation cost per unit of inventory. The least cost cell is allocated maximum quantity depending with the origin capacity of its row and destination requirement of its column then the next least cost cell is similarly attended. This pattern continues till all brim capacities and requirements have been satisfied. Usually, the total cost obtained in the initial basic feasible solution using the least cost method is lesser than that obtained using the North West corner rule for some reasons (Ndubuisi,P 2021). In most cases, the initial basic feasible solution using least cost method cannot be improved upon i.e. is also the optimal solution least cost implications.

iii**). Testing for Optimality**

There are two well-known procedures for this i.e)the steeping stone method and Modified distribution method. According to Henry (2012), optimality test is an attempt to survey the achievement of the objection function. The Stepping Stone (SST) Testing for optimality involves the individual assessment of all the empty cells/unused squares in the present solution. This process involves tracing a loop for each empty square by moving horizontally and vertically; and starting from the empty cell being assessed, assign (+) or (-) alternatively at each corner square of the loop. For each empty cell, only one loop exists. The tracing process may skip over stone and all empty cells.

In this regard, only the most direct route is used. The positive(+) or negative(-) signs shows the summation or deduction of one inventory unit to the cell. Net changes in total cost, resulting from the changes made in inventory unit additions or subtractions is obtained accordingly. This results from summing the unit cost in each square with a positive(+) sign and minimizing the unit cost in each square with a negative(-)sign. The difference in value is the improvement index for the unoccupied cell. In other words, an improvement index indicates by how much total cost will increase or decrease, if one inventory unit is allocated to that unoccupied cell in a new solution.

All the unoccupied cells are to be assessed similarly and improvement index is obtained. In the SST if the indices are all ≥ O (greater or equal to O), an optimal solution is said to have been obtained. Otherwise, an improved solution is possible,.

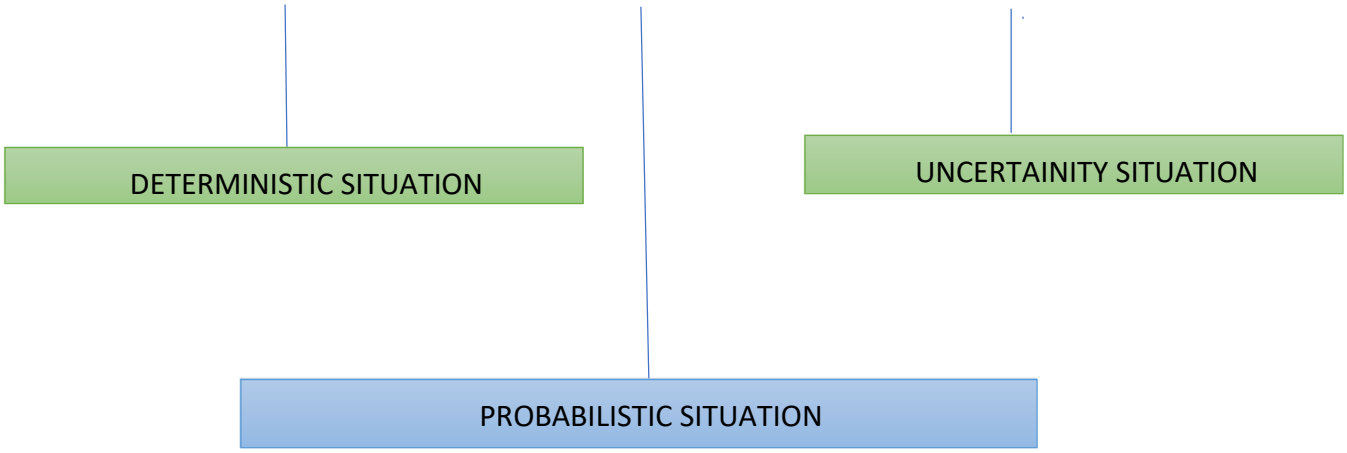
The Modified Distribution (MODI) Method approach, testing for optimality is done by the utilization of dual variables. The actual cost for each stone cell (basic variable) is determined. Then the implied cost and the opportunity cost is derived for each empty cell (non-basic variable). The cell with the highest positive opportunity cost is chosen as the most favourable empty cell. At this point, a closed path or loop is drawn for the empty cell in order to obtain a new basic feasible solution (incoming variable). When a new solution is developed, the same testing for optimality procedure is administered (after total cost table has been obtained). At the point in which opportunity cost for the empty cells are all ≤ O (less or equal to zero), the optimal solution is obtained, otherwise the solution can be improved upon. 4. Deriving the Optimal Solution The goal of the transportation technique is to establish the minimum total cost of transporting products/inventories from all known sources to all known destinations. This is realizable only at the optimal solution. Thus, the optimal solution is the final destination of any linear programming model. At this level, the solution can no longer be improved upon. Inventory allocations are finally made availing of optimal routes. In this way, organizations achieve prudence and efficiency in resource/inventory allocation and utilization. This is true because Baron (2005) defines the optimal solution as either the most profitable or the least costly International Journal of Management & Entrepreneurship Research, Volume 3, Issue 3, April, 2021 Ndubuisi, P.No.107-117 Page 112 solution that simultaneously satisfies all the constraints of a linear programming problem. In a typical problem, the search for this solution starts from the basic feasible solution and finally it is located at the boundary of the feasible region, that is at one of the corner points of the region

2.4.3 Games Theory

Games theory is concerned with Decision-Making in the conditions wherein multiple opponents are competing with conflicting interests towards winning. i.e. It deals with maximizing WINS or minimizing LOSSES before commencing of action. John von Neumann and Oskar Morgenstern,(1944)observed that economics is much like a game, wherein players anticipate each other's moves, and therefore requires a new kind of mathematics, which they called game theory. It focuses on questions like, What is my best decision in a given economic scenario, where a reward function provides a way for me to understand how my decision will impact my result.

Generally decision making situation can be classified into 3 different categories illustrated in the diagram below

Source: Chaudry Mkumar 2006



TERMINOLOGIES

1.Players – generally there are 2 players in the game for example Company A or Company B

2.Strategies- it means a course of action taken by a player for example a company will have different strategies to increase the volume of its sales .
3.Payoff – there are two players Player A and Player B with three strategies i.e 1,2 and 3 .the inner values of the matrix is the outcome of different combinations.If the outcome is positive then it is a gain to one player either A or B.

4.Maximin principle – maximizes the minimum guaranteed gains

5.Minmix principle – minimizes the maximum losses

6.Saddle point – the game will have saddle point if maximin value value and and minimax value are equal i.e the intersecting point will be equal

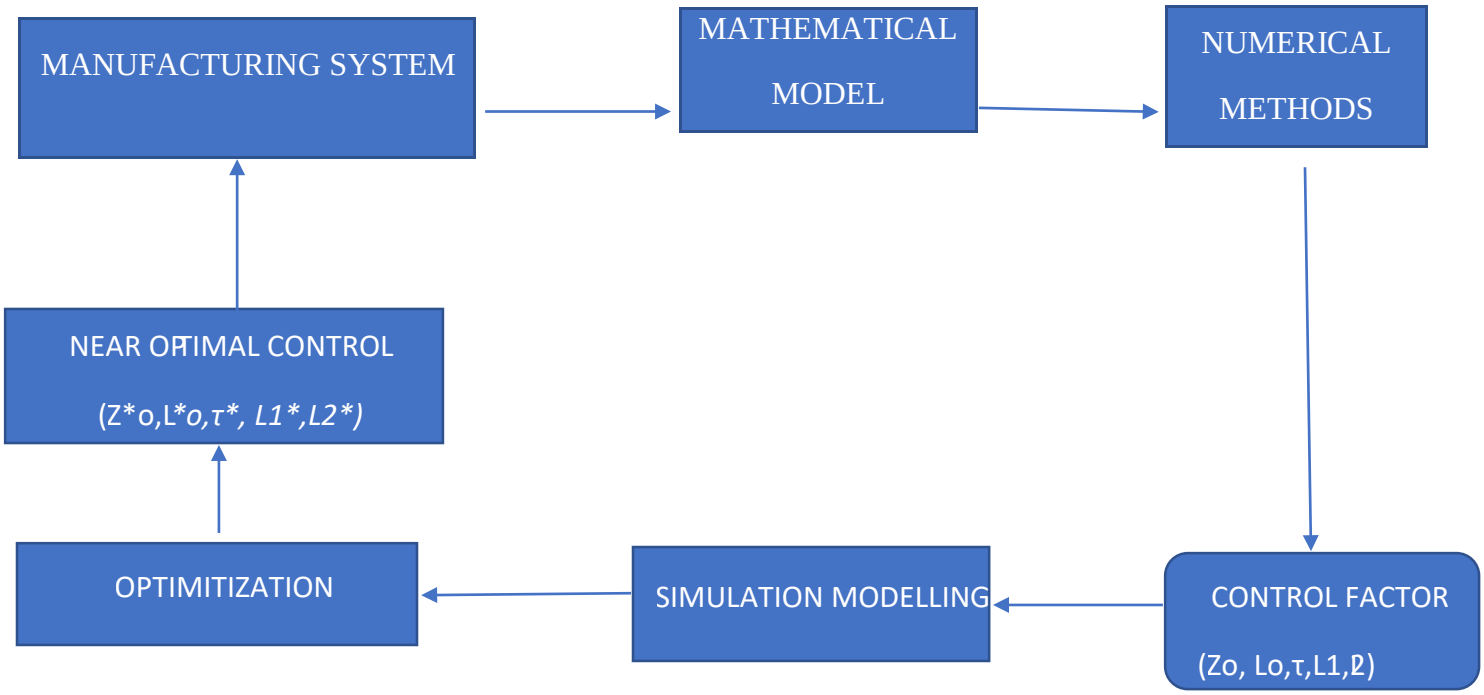
7.Value of the game – if the game has saddle point then the outcome in the cell at the saddle point is called the value of the game

2.4.4 Simulation

Simulation provides solution to the problems which are too expensive for experimental analysis and too complicated for mathematical treatment. To simulate means to imitate and experiment on the model of real-life phenomenon(Philips Z, Ginnelly L 2004). Computerised simulation modeling has become more common as a method of inquiry for operations management and the service industry since the 1990's. Quite a number of technology driven managers now rely on extensive use of simulation to test new ideas and options before actual implementation of their ideas Simulation allows the manager to both quantify and observe the system's behavior. Whether the system is a production line, a distribution network or a communications system, simulation can be used to study and compare alternative designs or troubleshoot existing operations. With simulation models, the manager can explicitly visualize how an existing operation might perform under varied inputs, and how a new or proposed operation might behave under same or different inputs.

There are 4 types of simulation models to leverage in business which include Monte Carlo Simulation, Agent based modelling and simulation ,Discrete event Simulation and Syatem Dynamics simulation.

To use the simulation model to solve the problem in business the following steps are mandatory



Source: Ali Garbi 2018

In 2010 the cost of managing the global supply chain reached between 7.7% and 9.3% of GROSS DOMESTIC PRODUCT(GDP) Zhao E. 2010, therefore any small improvement in the chain has the potential benefit to society , which is why the modelling and analysis of logistics systems stimulated worldwide(Arisha A. , Young P.2004) The stimulation modelling has proven to be a great tool for modelling complex environments. In logistics and production businesses the simulation can assist by analyzing the resulting events of logistical decisions and how they influence on the costs and their impact on organizational performance in a controlled environment. Deling L.2010 presented the analysis of logistics problems , considering the distribution and allocation of resources through a simulation model combined with optimization and showed the advantages of using this method compared to other simple mathematical analytical methods to study the location of distribution centres.

2.5 Empirical Evidence

Linear programming is one of the optimization techniques in finding solutions to managerial decisions making.Benin bakery (Nigeria) applied linear programming technique and intended to determine the quantity of Bread that the firm should produce in a day to maximize profits subject to constraints in the production process The problem was formulated in a mathematical term solved using computer software (LINEAR PROGRAMMING SOLVER).Fagoyibo I. and Ajibode T.(2010) carried out a research on maximization of profit in manufacturing industries using Linear programming technique. Based on the data analysis of the data collected it was observed that given the amounts of materials available used in production of the different products of the objectives value contribution and gave maximum profit at a given level of production capacity.

Maximization of profit is the pursuit of every business organization, profit itself is the excess of revenue over expenditure .To obtain profits increase in selling price of the product or reduction in the cost of production in inevitable. Uncontrolled cost could lead to higher operating costs lower profit marginal and dissatisfaction to the chairman of the company. In the case of Metro best international (Nigeria) which manufactures high quality bread(CHISCO bread) , the product is highly competitive in Enugu and its environment .The industry has 50staff comprising about 15 skilled and 35 unskilled .The bakery has one bus that ferry workers to and fro office and there is a shift for workers day or night ,they have 4 vehicles which they use in delivery of their products. Bakers Inn, are tasked with producing, selling and distributing quality flour products in Zimbabwe .The company started off in the 1980s as a small confectionery company employing 40 people and producing just 30,000 loaves per day. In 1998, a 150,000 loaf plant was commissioned at the Lytton Road plant and was recapitalized bringing the national capacity to 400,000 loaves. Bakers Inn offers customers on the go a wide range of freshly baked bread, rolls, confectioneries.

In the bread industry Bakers Inn being the giant competitor has always strived through with

Lobel's to gaining a more dominant market share. Proton being a small but also a major rival in the bread industry nationwide.However there are other small scale competitors in other cities where there are no major plants such as Mitchells', TN bakeries and other supermarket owned such as TM,Spar and OK.

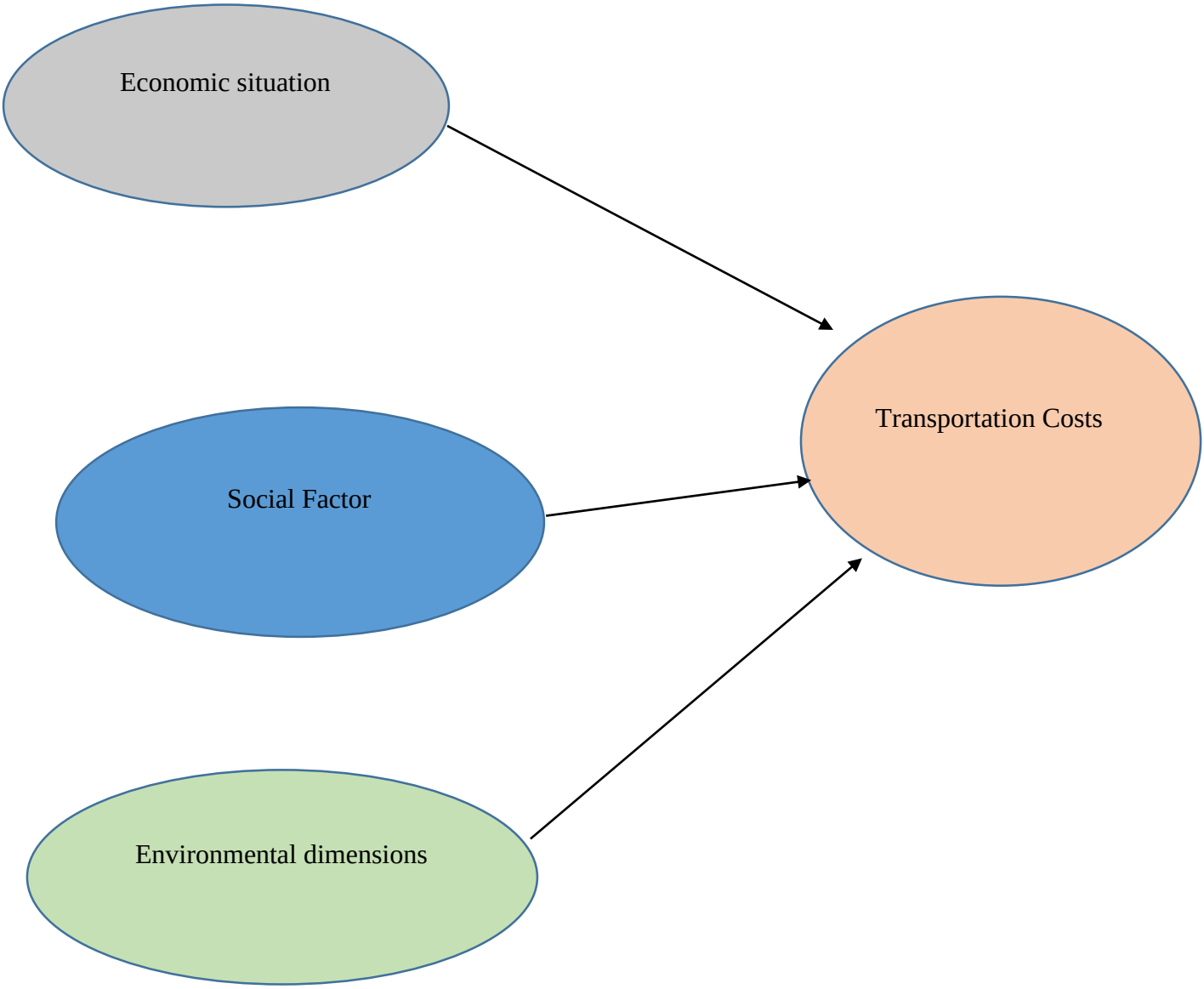
According to Miller(2007)the reason the versality of linear programming is due to ease at which constraints can be incorporated into the linear programming model. Balogun et al (2012) reported that the problem in production sectors is the problem of management that is faced by mmany companies with decision relating to the usage of manpower ,raw materials, capital etc. Joly(2012) reported that optimization is a crucial science for high performance refineries ,its main purpose in the oil manufacturing secto is to push production process or operation toward the maximal profit until it reaches the limit at which any further profitability increase depends on changes in the existing system .Ezema and Amaken(2012) argue that the problem of industries all over the world is a result of shortage of production inputs which result in low capacity utilization and consequently low outputs .This was applied in optimization of profit in golden plastic industry for the purpose of seeking and arriving at the optimal product –mix for production of plastics. AP Verma (2013) reports that the transportation problem is one of the sub-classes of linear programming problems in which the objective to is to transport various quantities of a single homogenous commodity , that are initially stored at various origins to different destinations in such a way that the total transportation costs is minimum.

Transportation problem is a special kind of linear programming problem in which goods are transported from a set of sources to a set of destinantions subject to the supply and demand of the source and destination respectively such that the total cost of transportation is minimized(R. Panneerselevan 2013). The aim of this study is to minimize the cost of transporting bread and confectionaries from 1 central factory to the nation's various retail shops.

2.6 Conceptual framework

Many firms are looking for ways to cut delivery time and costs by exploring opportunities to take advantage of technology. Fatemeh Farajzadeh (2022) refers the final transportation of goods from distribution centers towards customers as LAST –MILE delivery , which is often considers

as the most expensive and the most complicated process of a supply chain. He states that for most companies the distribution to the customers can account for up to 28% of the total transportation cost. From an operational perspective , optimal planning of the delivery routes constitutes a particularly challenging and costly problem because of the two mail global changes i.e the rise of e-commerce and rapid global urbanization(Joshua K Stolaroff, Constantine Samaras(2018). Application of mathematical modelling such as LLP Transportation model will analyze the processes and give solutions to such problems.



Source Rameshwar Dubey : 2010

The economic criteria determines an economy's contribution that affects transportation and has resonating Long term effects .For instance the hiking of fuel may adverse effects on the transportation costs. It leads to overloading of trucks and may pose major threat to the supply and customers (Golicic et al., 2010). Costs of transportation are positively impacted by social considerations. In recent years, the transportation mix has been substantially impacted by the unemployment rate and widening class disparities. (2011) Vlek and Steg The main bakeries view it as a chance to develop the business without taking into account the profit and expenditure component because of the population growth and urbanization as well as the bad infrastructure that prevents other sectors from operating in particular surroundings. Concerns about sanity and environmental protection are emerging. Nevertheless, there are numerous environmental norm violations despite the numerous efforts made by NGOs and government organizations. As a result, environmental factors have a favorable effect on transportation expenses.

2.7 Gap Analysis

. Given the context of the study, Bakers Inn Zimbabwe, and the fact that there have been fewer studies on the subject under examination, the researcher's study differed significantly from other studies that have been done in the past. The studies mentioned above were conducted primarily in industrialized nations, where a variety of facilities are employed to control the production of bread and confections. In contrast to Bakers Inn, which relies solely on a single production facility when it is a major distributor, several research concentrated on minimizing the total costs in systems with many plants. The majority of the research done for Bakers Inn concentrated on improving revenue collection, with some studies also analyzing the quality of service delivery, although not many.

2.8 Chapter Summary

The preceding chapter, which focuses on research methods, covers the literature review, which includes a conceptual framework, theoretical literature, empirical data, and a gap analysis.

Chapter 3

Research methodology

3.1 Introduction

This chapter introduces the logical framework to be followed to meet the objectives stated in the first chapter of this study. The research design, population of interest, data instruments and how the data will be collected and analyzed to come up with findings, interpretations and conclusions are discussed in this section.

3.2 Research methodology

According to (Kothari, 2004), methodology is a methodical approach to tackling the research problem and can be viewed as a scientific method of examining how research is conducted. According to (Leedy, 2015), research technique is the systematic, organized, and targeted collecting of data with the goal of learning more in order to answer research questions. The researcher's goal in this study is to develop and put into practice strategies that Bakers Inn could employ to cut operational costs. Primary data sources are more important to use for achieving this goal.

3.3 Research Design

Research design, according to Saunders et al. (2009), is the broad strategy for how the researcher would approach answering research questions. It defines data sources and takes into account the limitations that the researcher would unavoidably have. This study will employ an explanatory research methodology because its primary goal is to provide the factory with comprehensive guidance on supply management costs that incurs the fewest expenses possible. It is necessary to describe in detail how optimization aid in decision-making and planning that reduces operational expenses. It is also necessary to explain the significance of the findings from data analysis.

3.4 Target Population

Target populations are any individuals or objects (units of analysis) that fit the study's criteria, according to Bhattacherjee (2012:65). Target population, according to Saedah (2014), is a specific set of people who are known to be the targeted audience for an advertisement, a product, or a campaign that makes it possible to conduct an interview. Members of the production, audit, and logistics departments were the target audience for this study.

3.5 Sampling technique

A purposive sampling technique is a non-probability sampling that selects a sample based on the characteristics of the population and the objective of study (Saunders et al., 2009).The researcher chose purposive sampling to select only those with adequate information pertaining the subject under study thus the researcher focused on the logistics department which deals with transport and delivery from place to place costs and the finance department.

3.6 Sample Size

(Bhattacherjee, 2012) is of the opinion that a sample is the actual units selected for observation. For this study, the sample size includes two logistics department members at BakersInn, the production team and three delivery teams. The researcher used a sample of 2 logistics department members, 3 finance department members and 2 members of the delivery teams'

3.7 Sources of data

The researcher would base her conclusions on the results of this study, therefore in order to draw meaningful conclusions, she mainly drew on both primary and secondary data that were gathered. It is possible to answer specified research questions, test hypotheses, and assess results through the process of collecting data on relevant variables in a systematic and established manner.

The necessary research funding was gathered either from the statistics department or from the GAAP (Generally Accepted Accounting Principles) data source maintained by Innscor Limited.

3.7.1Primary data

It is the data that is original information which will be gathered from the field of interest .The data obtained was used to clarify the questions and objectives of the exploration study.

3.7.2 Secondary data

It is the historical information that has already assembled and gathered for different research issues with the current scope of research area. The secondary information for the exploration on the impact of sales promotion on sales of Bakers Inn was consulted, collected and accessed from various sources which incorporate, organization journals and past researches. To add on, some of the data relating to private brands was collected from the relevant reading material within web sites. More so, the researcher attained secondary data because it was promptly accessible at whatever point it was asked for and likewise to compare with primary data results so as to come up with a sounding conclusion on each research objective.

3.8 Research Instruments

(Saunders et al., 2009) said research instruments are tools that are used to collect data in a systematic way . LINGO and EXCEL software were used to carry out the data analysis with the use of internet GAAP(Generally accepted accounting principle) for extraction of data and statistics department.

3.8.1 LINGO package

The results were produced using the optimization applications EXCEL and LINGO in addition to other programs like MATLAB or TORA that could be used. Because of its simplicity, LINGO was chosen by the researcher. When a problem is complex, this program is more helpful. When there are a lot of decision-making variables involved in the problem, it might become difficult. The usage of LINGO software necessitates the availability of data about the environment surrounding the problem, and operations research has developed unique methodologies that can measure, compare, control, and forecast potential behavior of the system's variables using a scientific approach. Writing Inc. (2018)

3.9 Observation

(Zikmund, W.G, 2003) defined an observation as a way of gathering data by watching behaviour, events or noting physical characteristics in their natural setting. Participant observation was used as a way in examining the problem at hand. Having been an attachee student at Bakers Inn and knowing most shops run under the brand name contributed to the observations. Most of the products are written off as waste as they would have been stale quickly due to late delivery. The baked products need about two days to stay and consumed fresh but to distant towns the day would have passed while transporting. All together this has contributed greatly to grasp and understand the Bakers Inn system used in supply and demand.

3.10 Data analysis and presentation

Data analysis is characterized as the transformation and modeling of data with the purpose of identifying relationships to aid in research. According to Alexopoulos (2010), data analysis seeks to derive reliable information from unprocessed data. Displaying statistical data that has been evaluated makes it easier to understand trends.

The general linear programming model with n decision variables and m constraints can be stated in the following form.

Optimise (min or max) Z = $c_1x_1+c_2x_2+\ldots\ldots\ldots\ldots\ldots\ldots..c_nx_n$ *s.t*

$$a_{11}x_1+a_{12}x_2\ldots\ldots\ldots\ldots\ldots\ldots a_1(\leq, =, \geq)b_1$$

$$a_{21}x_1+a_{22}x_2\ldots\ldots\ldots\ldots\ldots\ldots a_2(\leq, =, \geq)b_2$$

.

. .

$$a_{m1}x_1+a_{m2}x_2+\ldots\ldots\ldots\ldots\ldots\ldots(\leq, =, \geq)b_m$$

Wherec_1, c_2, ……..c_n Represents the unit cost of decision variablesx_1,x_2 ,……..x_n to the value of objective function.

And $_{11}$, a_{12} …… . a_{2n}…….a_{mn} represent the amount of resources consumed per unit of decision variable.

Represent total availability of the i^{th} resource

Z represent the measure of performance which is profit in our case.

3.10 LLP Transportation Model

(Jeff Heyl 2011) defines transportation modeling as an interactive procedure that finds the least costly means of moving products from series of sources to a series of destinations.This model can be used to resolve distribution and location decisions. According to (Martin Gibbs 2003) transportation model is a method of finding out the optimal way to achieve a goal with minimum resources used. It addresses the concept of moving a thing from one place to another without

change. The main aim is to develop an optimized transporting plan that results in a minimum of cost. The following assumptions must be applicable

3.10.1 Assumptions of Transportation model

1. Items are homogenous
2. Transporting costs per unit are the same no matter the quantity
3. Only one route is chosen between the origin Objective function

Minimize $\sum_{i=1}^{m}\sum_{i=1}^{n} C\ ijXij$

Constraints

$$\sum_{j=1}^{n} Xij \leq a\ ij$$

for i= 1,2,…,m

The total outgoing products from this warehouse is the sum ($x_{i1+}\ x_{i2}+\cdots.+xin$)In summation notation, this is written as $\sum_{j=1}^{n} x_{ij}$. Since the total supply from warehouse i is , the total outgoing shipment cannot exceed a_i .

3.10.2 Intiutive Approach

This is the appropriate feasible distribution plan which looks at the cost starting with the lower costs and reallocating units to a certain cell.

3.11 Chapter Summary

The data gathering methods, data analysis process, and research design were highlighted. The representation, analysis, and discussion of data are the main topics of the next chapter. The

chapter's structure was determined by the recommendations given by earlier research that were covered in the second chapter. A discussion of the results and suggestions based on the findings follows below.

Chapter 4

DATA PRESENTATIONS,FINDINGS AND ANALYSIS

4.1 Introduction

The researcher's focus in this chapter is on the presentation of the results as well as the analysis of the data that was gathered. According to the first chapter, linear programming was used to examine the data. Due to their proficiency in the analysis of data from linear programming, the calculation and presentation of findings were achieved using the LINGO programming software package. The

outcomes allow us to respond to inquiries about the linear programming model that can assist in maximizing profits and what is the produced LP model's ideal solution..

4.2 Analysis of Data and presentation of the findings

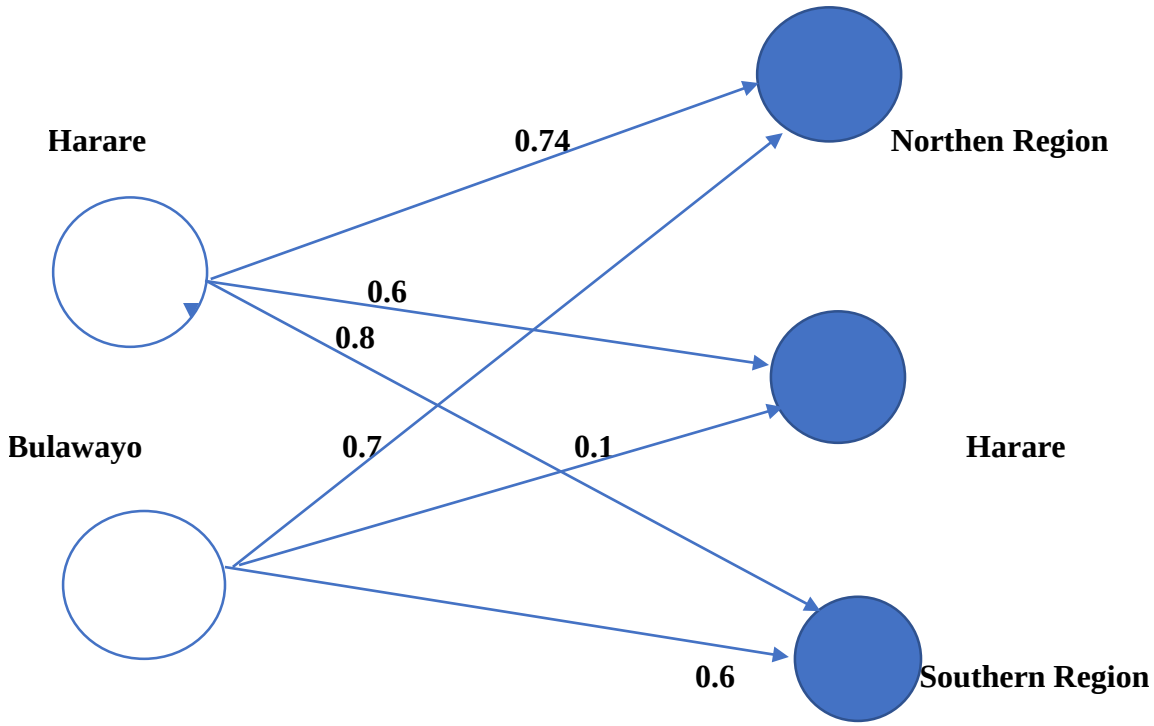
Simbisa Brand Limited in Zimbabwe provided the information for this study project (BAKERS INN). The information includes total daily sales of bread and confections, daily purchases, average daily production amounts of bread and confections, and profit contributions by produced category. EXCEL and LINGO version 18.0 applications were used to analyze the data.

FIG 4.1 TRANSPORTATION PROBLEM

	Northern region	Harare region	Southern region	Supply
Harare	0.74	0.6	0.8	450000
Bulawayo	0.7	0.1	0.6	220000
Demand	95624	258044	180502	

The table above shows the collected data, sources supply, costs and destination demand. regions the products are delivered to.

FIG 4.2 TREE DIAGRAM



4.3 Model formulation

Let the x_1 be product transported from Harare factory to Northern region shops

Let the x_2 be product transported from Harare factory to Harare shops

Let x_3 be the products transported from Harare factory to Southern region shops

Let x_4 be the products transported from Bulawayo factory to Northern region shops Let

$x_5$be the products transported from Bulawayo factory to Harare shops

Let x_6 be the products transported from Bulawayo factory to Southern region shops

Or

x_{ij} = products transported from plant *i* to Destination *j* *Where i* = Harare(H) and Bulawayo(B) *j* = (NR) Northern region ,(H) Harare ,(SR) Southern Region

4.3.1 Original

Min Z= 0.74x11 + 0.6 x12 + 0.8x13 + 0.7X21 +0.1x22+ 0.6x23

St

X11+x12+x13 +0x21+0x22+0x23< 450000

0x11+0x12+0x13+ X21+x22+x23 < 220000

X11+x21 = 95624

X12+x22 = 258044

X13+x23 = 18050

Xij>= 0

4.3.2 Coded/Modified to fit excel and lingo

Objective function

Minimize Z= 0.74 x_1+0.6x_2+0.8x_3+0.7x_4+0.1x_5+0.6x_6

s t

$$x_1+x_2+x_3 + 0x_4 + 0x_5 +0\ x_6 \leq 450000$$

$$0x_1 +0x_2 + 0x_3 + x_4+x_5+x_6 \leq 220000$$

$$x_1+x_4 = 95624$$

$$x_2+x_5=258044$$

$$x_3+x_6=180502$$

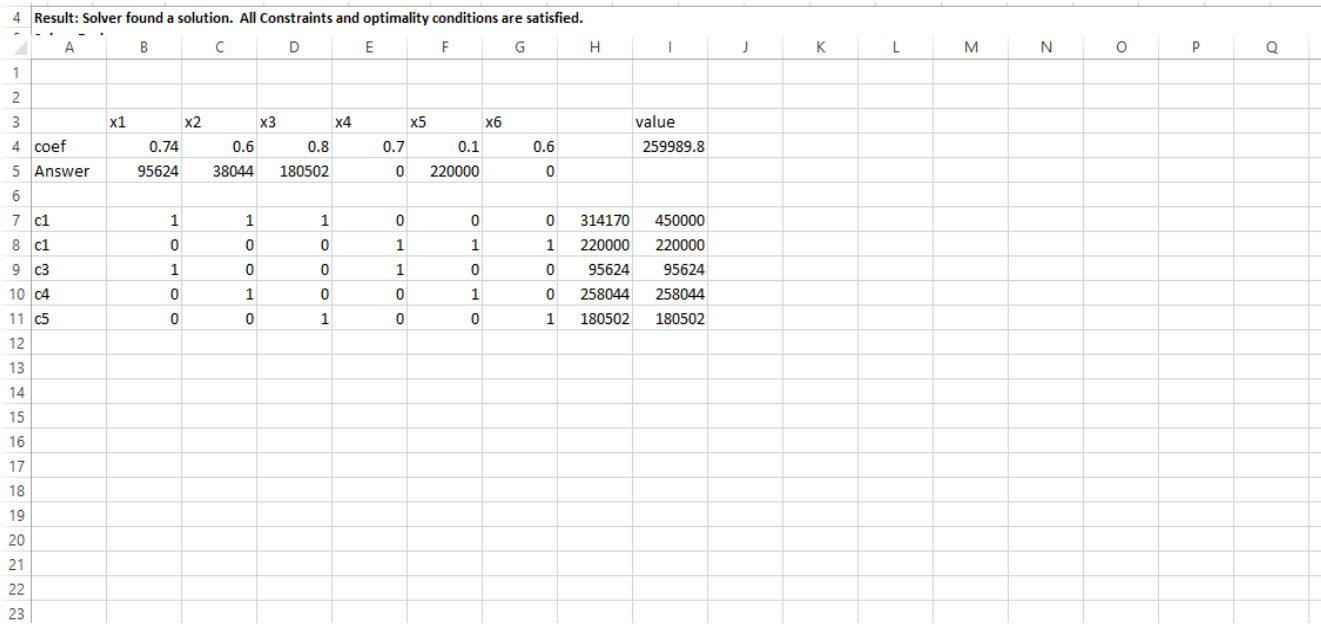
$$x_{ij} >= 0$$

A LINGO solver code was prepared to solve the transportation problem case study that is in this research. Fig 1.3 illustrates the prepared Lingo based on the transportation problem formulation above to solve and reduce/minimize the costs for longer distances.

4.4 Interpretation of results

Using the data gathered, the model's best outcome suggests that Harare factory should on supply in the northern region and Harare region only whilst Bulawayo supplies in the southern region and partly Harare. There shouldn't be a reduction on the number of products supplied in Bulawayo and the reduced costs will amount to approximately $260000.

FIG 4.3



Result: Solver found a solution. All Constraints and optimality conditions are satisfied.

	x1	x2	x3	x4	x5	x6		value
coef	0.74	0.6	0.8	0.7	0.1	0.6		259989.8
Answer	95624	38044	180502	0	220000	0		
c1	1	1	1	0	0	0	314170	450000
c1	0	0	0	1	1	1	220000	220000
c3	1	0	0	1	0	0	95624	95624
c4	0	1	0	0	1	0	258044	258044
c5	0	0	1	0	0	1	180502	180502

.

The above tableu shows that a minimum cost of $259989.8 can be obtained if bread is delivered from Harare factory to northern region (95624) ,Harare factory to Harare region (38044) , Harare factory to Southern region (180502) . From the tableu c2,c3,c4 and c5 are exhausted and c1 has an excess of 135830 units. This means all the units(bread) supplied in HR and SR from Harare region are utilized and all from Bulawayo to the 3regions are utilized as well. Units supplied

from Harare factory to NR are left unexhausted and this may result in wastage, thereby costing the production department.

4.5 Discussion of findings

Reduced cost is the amount that would need to be improved in an objective function coefficient (i.e., increased for maximizing problems, decreased for minimization problems) before a corresponding variable might take on a positive value in the ideal solution. M Tamer Ayvaz 2013 proposed a linked simulation optimization model to reduce groundwater pumping costs for existing wells and new to satisfy any given water demand.The identification results of the proposed models depended on selection of some solution parameters and also a sensitivity analysis was vital in this findings. In the research done by Lisheng Wang and Nan Jiang (2013) for warehouse optimization in shipping goods , a generic algorithm was used to solve and optimize the problem. The findings were to determine a location and study it for improvement in the global scalabity for the future. Before optimization the average cost of getting good to its destination per unit was $4.523 and after optimization was $ 4.289. The analysis concluded that the transportation model can improve the efficiency of transportation.

Findings by Fibi Eko Putra (2020) in relation to the similar study for transportation of common goods excplained that the cost of transporation from warehouse to the customer was $1.787 per kilometer. The distribution of goods using Excel solver method transporation model is $4.0295. The model reduced costs from $4.035 and that is 0.21% of the original costs. Therefore the hypothesis and method is acceptable.

4.6 Simplex method

FIG4.4

Worksheet: [Book1]Sheet2
Report Created: 12/13/2022 1:33:32 PM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.015 Seconds.
Iterations: 5 Subproblems: 0
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$I$4	coef value	314140.36	259989.8

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$5	Answer x1	95624	95624	Contin
$C$5	Answer x2	218546	38044	Contin
$D$5	Answer x3	0	180502	Contin
$E$5	Answer x4	0	0	Contin
$F$5	Answer x5	39498	220000	Contin
$G$5	Answer x6	180502	0	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$H$7	c1	314170	$H$7<=$I$7	Not Binding	1E+05
$H$8	c1	220000	$H$8<=$I$8	Binding	0
$H$9	c3	95624	$H$9=$I$9	Binding	0
$H$10	c4	258044	$H$10=$I$10	Binding	0
$H$11	c5	180502	$H$11=$I$11	Binding	0

The report above shows the final value of 259989.8 as the minimum cost of supplying 314140 units(original value). It also indicates that the constraints 2-5 are binding (satisfied with equality at the solution) and only constraint is not binding(not satisfied). There fore all the supplies in constrains 2-5 are exhausted in the final solution. Constraint 1 is not binding with 1+E05 meaning infinity cost of slack. Slack is the difference between final value and and the lower or upper bound imposed by a constraint (Diane M. Ring 2021) . This means there is a cost of 1+E05 that is not consumed in supplying the units to produce the final solution. In general if the status shows binding then the slack should be 0 and if status is not binding slack must be a positive number(Clemson U 2018).

4.7 Sensitivity analysis

FIG4.5

Worksheet: [Book1]Sheet2
Report Created: 12/13/2022 1:33:32 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$5	Answer x1	95624	0	0.74	0.46	1E+30
$C$5	Answer x2	38044	0	0.6	1E+30	0.3
$D$5	Answer x3	180502	0	0.8	0.3	1E+30
$E$5	Answer x4	0	0.46	0.7	1E+30	0.46
$F$5	Answer x5	220000	0	0.1	0.3	1E+30
$G$5	Answer x6	0	0.3	0.6	1E+30	0.3

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$H$7	c1	314170	0	450000	1E+30	135830
$H$8	c1	220000	-0.5	220000	38044	135830
$H$9	c3	95624	0.74	95624	135830	95624
$H$10	c4	258044	0.6	258044	135830	38044
$H$11	c5	180502	0.8	180502	135830	180502

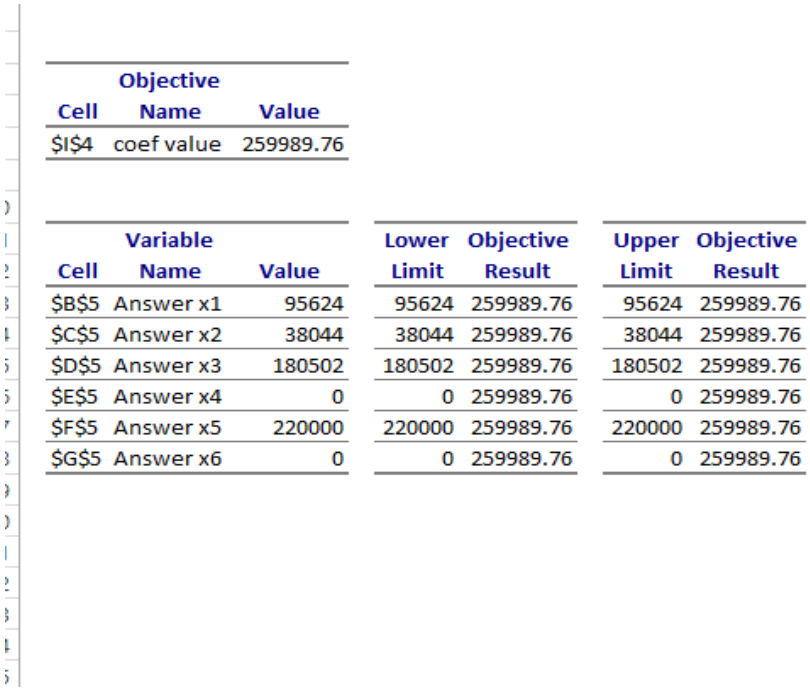
Sensitivity analysis helps to study how the optimal solution is affected by the objective function coefficients and to see how the optimal value is affected by the right hand side(RHS) values.In this case the variable x4 will decrease profit at 0.46 cost per unit and x6 at 0.3 and the other variables(x1, x2,x3 and x5) remain optimal. For instance if the coefficients on x1 is raised to 0.74+0.46=1.20 or decrease to 0.74-1.0003=-0.26 The optimal plan is to supply 95625 units in the Northern region , for x2 the supply should be 38044 , for x3 180502 and 220000 for x4.

Therefore the objective coefficient ,Allowable increase and allowable decrease column aboves give us the conditions for which final values obtained remains unchanged. This means the cost varies between 0.74 and 0.6 per unit.

The shadow price indicates how the objective function will change when the constant on the RHS is changed.In the above table the shadow price for the constraint 1 is 0 and it requires the factory to supply at least 314170 units and the constraint is not binding .This indicates that if the supply is increased by 1 or more the corresponding cost at the optimal solution will not change ,it will neither increase nor decrease. The allowable increase is shown as 1E+30 , this is Excel's way of showing infinity.This means that the constraints on RHS (supply) can be increased by any amount without changing the shadow price. This makes sense since increasing Harare's capacity of supply simply adds more excess units to the regions and will not change the feasible region.Similarly if the supply for constraint 2 is increased or decreased by 1 or more the cost will decrease with a negative cost of 0.5. For constrains 3,4 and 5 the shadow price for each supply are positive which means if either supplies are increased or decreased the costs for each constraint will increase or descrease with its corresponding shadow price . In this case since the size of the feasible region changes the optimal solution changes to a new value.

4.8 LIMITS REPORT

Fig 4.6



Objective		
Cell	Name	Value
$I$4	coef value	259989.76

Variable			Lower	Objective	Upper	Objective
Cell	Name	Value	Limit	Result	Limit	Result
$B$5	Answer x1	95624	95624	259989.76	95624	259989.76
$C$5	Answer x2	38044	38044	259989.76	38044	259989.76
$D$5	Answer x3	180502	180502	259989.76	180502	259989.76
$E$5	Answer x4	0	0	259989.76	0	259989.76
$F$5	Answer x5	220000	220000	259989.76	220000	259989.76
$G$5	Answer x6	0	0	259989.76	0	259989.76

This report provides a specialized kind of sensitivity analysis information which tells how the value of the objective function changes as each variable is maximized and minimized while all other values are held constant and while satisfying the problem's constraints. In the above report the costs for shipping the total units was $259989.76. The lower limits value is the lowest valkue that each variable can take on and still satisfy all the constraints and the values shown in the upper limit reflects the highest value that each variable can take.

4.9 Conclusion

Though this model has some limitations , if the company applies it the solution reached through this study it will be able to minimize the transportation costs which will result in increased profitability. In future a more optimized model of this problem can be developed by getting rid of limitations but certainly there will be some real life constraints which may not be solved with any model. In those cases there will be dependancy on experience and intuition.

CHAPTER 5

Conclusions, Summary and Recommendations

5.1 Introduction

The purpose of the current chapter is to provide an overview of the research as well as conclusions and recommendations about the use of linear programming for cost minimization. The research aims and recommendations for utilizing the linear programming model as a management tool for decision-making are highlighted in this section's important findings and conclusions. The researcher anticipates that Simbisa Brands (Bakers Inn) will utilize the findings and use them as the foundation for successful cost-cutting measures. The conclusions in the preceding part and the goals of the research study served as the foundation for the recommendations and proposals.

5.2 Summary of findings

The objective of this research work was to apply linear programming for cost minimization at Bakers Inn. Simibisa Brands limited (Bakers Inn brand) was used as our case study. The decision variables in this study are shipping cost, plant (source) and destination(3 regions of Simbisa Brands NR,HR and SR) drawn from the production, logistics and finance department . The researcher focuses mainly on 2 major deports in the regions which are Bulawayo and Harare .

5.3 Recommendations to Future Researchers

Simbisa Brands should put some steps in place to help achieve the goals outlined in the first chapter based on the study's findings.

-

- The company should consider establishing more factories in the major cities which will also supply in the remote areas since its expanding yearly.
- Production team should have a daily restricted order plan from various shops to avoid wastes.This may be accounted for if all the staff members attend to its daily sales before production.
- They ought to conduct comparable studies utilizing alternative methodologies to those used in this study
- Given that mathematical modeling is crucial to providing services, it must be examined.
- They can apply a similar process to assist with additional services at Bakers Inn or for other bakeries.
- They should complete the project taking into account the entire community.

The concept of Linear Programming is a powerful technique in the management and a tool used for decision making, as shown in literature review. I suggest that the upcoming researchers on linear programming, will look at its applicability in profit maximization of other industries in Zimbabwe and also its applicability in optimization and resource allocation. The developing economy can employ this management tool, to effectively make sound decisions that will increase profit margins, profit maximization and efficient use of available raw materials.

5.4 Conclusion

According to the analysis done for this research project and the results presented, Bakers Inn Zimbabwe Harare should consider the supply ranges for each plant or rather implement measures or establish more bakery plants in major cities such as Mutare which is included in the northern region and Gweru and Masvingo which is included in the Southern region. Advantage will be for both to the supplier and consumer. Many of the employees at Simbisa Brands are proficient in operations research techniques and have a thorough understanding of the company environment

as well as managerial responsibilities. I advise the company to hire and establish a department of such consultants to use this and other strategies to management's decision-making issues. At the very least in the medium term, this can greatly help the logistics and finance department.

However, having permanent specialized personnel who can suggest possibilities to use the new techniques would definitely be beneficial in the long run for many businesses with the similar processes. In addition to having the necessary computer skills for handling the complexity of the mathematical techniques involved in issues like these, there should be individuals who can effectively and efficiently interpret the outcomes of mathematical analysis to the top logistics management team in the company's specific context.

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