THE TRANSPORTATION PROBLEM OF A BEVERAGE INDUSTRY:

A CASE STUDY OF ACCRA BREWERY LIMITED. (ABL)

By

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CERTIFICATION

I hereby declare that this thesis is my own work towards the award of Degree of Master of Science in Industrial Mathematics and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University except where due acknowledgement has been made in the text.

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DEDICATION

This thesis is dedicated to my husband Rev. Patrick Kofi Ntim-Manteaw and my lovely children, Reynolds, Georgina and Patrick (Jnr).

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ABSTRACT

Road transport is a predominant means of commuting in Ghana and accounts for high passenger travels and carting of goods in the country, making it a vital transportation service that links the country to others in the entire West African sub-region. Road transport is by far the dominant carrier of freight and passengers in Ghana's land transport system. It carries over 95% of all passenger and freight traffic and reaches most communities, including the rural poor and is classified under three categories of trunk, urban and feeder roads.

Every business establishment involves production. The production making aspect of the business involves the use of inputs made up of materials, labour, energy and other resources and the generation of outputs of finished goods/products.

These production sites are linked by road transport to supply points; managers and organizations require proper tools for decision making so they can be effective in increasing accuracy and quality of decision.

In this study, the transportation problem of Accra Brewery Limited (ABL) was considered.

Both primary and secondary data from ABL was obtained and modeled as a transportation problem.

The Vogel's Approximation Method (VAM) was used to find the initial basic feasible solution and improved to optimality by the use of the Modified Distribution Method (MODI) using computer software, Quantitative Manager for Windows (QMW). It was observed that, during the lean season, the optimal cost of transportation was GHc50, 576.83 and that of the festive season was GHc86, 853.10. The results showed that there was much difference between the

optimal costs of the lean season and that of the festive reason. Because of that it was recommended that during the festive season, the company could produce more and supply most of the products within the same region where they are being produced to ensure minimum cost and increase profits.

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CHAPTER ONE

INTRODUCTION

1.0 Brief introduction

This first and foremost chapter discusses the background of the study statement of the problem, objectives of the study and methodology. It further talks about justification of the study, limitations of the study and finally organization of the study

1.1 Background of the study

The main problem manager's face in recent times is how to allocate or distribute scarce resources among various needs or projects. Linear Programming (LP) is a mathematical technique used in computer modeling (simulation) to find the best possible solution in allocating limited resources (energy, machines, materials, money, personnel, space, time etc) to achieve maximum profit or minimum cost. However, it is applicable only where all relationships are linear, and can accommodate only a limited class of cost functions

It is one of the most widely used tools in operations management. LP has been a decision making tool in almost all manufacturing industries and financial service organization. What makes the course of society and its economic and governmental organizations to steer up and worth – is mainly the work of solving the problems and making decisions.

Road transport is a predominant means of commuting in Ghana accounting for high passenger travels and carting of goods in the country making it a vital transportation service that links the country to others in the entire west African sub-region.

Transport in Ghana is accomplished by road, rail, air and water. Ghana's transportation and communications network are centered in the southern regions, especially the areas in which gold, cocoa, and timber are produced. The northern and central areas are connected through a major road system; some areas however, remain relatively isolated. Road transport is by far the dominant carrier of freight and passengers in Ghana's land transport System. It carriers over 95% of all passenger and freight traffic and reaches most communities, including the rural poor and is classified under three categories of trunk roads, urban roads and feeder roads. The Ghana Highway Authority established in 1974 is tasked with developing and maintaining the country's trunk road network totally 13,367km, which makes up 33% of Ghana's total road network of 40,186km (http://www.highways.gov.gh/index).

Every business establishment involves production, thus making changes to materials and turning them into goods and services.

The production making aspect of the business involves the use of inputs made up of materials, machines, labour, energy and other resources, and the generation of outputs of finished goods or products and other outcomes.

Managers usually would want to know how effectively various processes operate with regards to multiple inputs and outputs. The transport system faces the challenge to increase their capacity and to reduce the cost of movements. All users have to negotiate or bid for the transfer of goods, people, information and capital, because supplies, distribution systems, tariffs, salaries locations marketing techniques as well as fuel costs are changing constantly. There is also cost involved in gathering information, negotiating, enforcing contract and doing transactions which are often referred to as cost of doing business. Most often individuals and enterprises must decide on how to route passengers or freight through the transport system. This choice of selection has been expanded in the context of the production of lighter and higher value customer. It is not common for transport cost to account for as low as ten percent (10%) of the total cost of a product. Thus, the choice of a transportation mode to route people and items between the point of production (origins) and points of delivery (destinations) becomes important and depends on some factors such as nature of goods, the available infrastructures, origins, and destinations, technology and most importantly the respective distance involved. Jointly and severally, these factors listed above define transportation costs.

Transport costs are the costs involved in relaying goods to and from a plant including payments to transport firm for their services and any cost incurred by plant in using and maintaining its own fleet of vehicles.

Many simple models, such as Von Thunan and Weber view transport cost s as:

(i) proportional to distance

(ii) Each additional unit of distance adds an equal increment of cost; but in reality

transport costs are less than proportional to distance – why?

The existence of fixed cost of transport facilities incurred regardless of length of journey/distance. Furthermore, fixed or terminal costs (interest on capital, cost of maintaining plant and equipment, depreciation) dilute the unit cost as distance increases.

Finally therefore, cost per kilometer tends to decline with increase distance.

Transport costs are monetary measure of what the transport provider must pay to produce transportation services. They come as fixed (infrastructure) and variable (operating) costs, depending on a variety of conditions related to geography, infrastructure, administrative barrier, energy and on how passengers and items are carried. The impact of transport cost on international trade as well as on the structure of economic activities is very significant. It is widely acknowledged that transport has a crucial role to play in economic development. More specifically, it has been recognized that the provision of high transport system is a necessary precondition for the full participation of remote communities in the benefit of national development. Adequate, reliable and economic transport is essential although not in itself sufficient for the social and economic development of rural areas in developing countries. The direct impact of transport on production at remote locations is derived from three effects thus, lowering of production cost, increased producer prices and encouragement of investment.

In general, transportation costs in international trade are higher as compared to those in domestic trade. This is because in domestic trade the transportation of goods traded takes

Place only within the national boundaries, while that in international trade takes place across countries, beyond the national boundaries. Thus transportation cost increases the effective purchase price of products. This means that the international trade becomes an attractive trade proposition where the economics of specialization at national level more than offsets the cost of transportation.

In a competitive environment where transportation is a service that can be bided on, transport costs are influenced by the respective rates of transport companies, the portion of the transport costs charged to users.

Rates are the price of transportation services paid by their users; they are the negotiated monetary cost of moving a passenger or a unit of freight between a specific source and destination. They are often visible to the consumer(s) since transport providers must provide this information to secure transactions. Notably among the costs that transportation service may incur are fuel maintenance, labour etc. Considering the limitations of resources, coupled with the need for the quality of services for freight and passengers transportation, there is obviously the need for transport companies to optimize the use of current resources. Certain considerations are worth noting when considering transportation. One needs to have in mind security, port selection, inland and delivery movement. In addition to the above listed transportation concerns, distribution-related issues such as packing / package, transit insurance, import duties, method financing and handling / loading must also be given an attention. Freight companies projecting large volume movement can encounter serious transportation problems in the distribution of their products of which Accra Brewery Company Limited (ABL) is not an exception. This company encounters a lot of challenges in transporting the beverages produced by the company.

Accra Brewery Company Limited is a company based in Accra, Ghana. Accra Brewery Limited (ABL), originally known as Overseas Brewery Limited was resisted in 1931 for the purpose of stabling a brewing industry in the then Gold Coast. Following a new investment law passed in 1975, there was a revision of ownership and the name changed to the current one. Again in 1997, South African Breweries acquired controlling shares in the company. ABL is one of the oldest non-traditional manufacturing businesses in Ghana. They are listed on the stock index of the Ghana Stock Exchange, the GSE All-share index. ABL prides herself on the quality of her brands including club beer, castle milk stout, stone lager, club shandy, vitamalt, and muscatella which are produced and marketed from their site in Accra and Kumasi.   Sales volumes of some 400,000hl represent slightly under a third of the total market. ABL is well positioned to capture growth in all beverage categories.

ABL has one billion authorized shares of which 249,446,664 are issued making its stated capital GH¢7,332,000.00. It has Overseas Breweries Limited as its major shareholders with about 62.9% of the shares outstanding. It is also the second largest brewer in Ghana and has distribution depots all over Ghana.

Despite all these statistics, ABL faces the problem of how to effectively supply its numerous products to its numerous customers at a minimized cost.

With such large products to supply, there is the need to understand the transportation problem. The transportation problem is one of the subclasses of linear programming problem where the objective is to transport various quantities of a single homogeneous product that are initially stored at various origins, to different destinations in such a way that the total transportation is minimum.

Depending on the nature of the cost function the transportation problem can be put into two categories namely linear and non-linear transportation problems. It is always assumed that the distance from every source to every destination is fixed. In order to solve the transportation problem, we have at least five methods namely:

(i) North- west corner method

(ii) Minimum cost method

(iii)Vogel's Approximation method (VAM)

(iv)Row Minimum method

(v) Column minimum method

However, comparison between different solutions is done for choosing less value of the objective function so that the user will be able to make decision.

The transportation model is a special type of network problems that for shipping a commodity from source (e.g. factories) to destinations (e.g. warehouse)

Transportation model deals with how to get the minimum cost plan to transport a commodity from a number of sources (m) to a number of destinations (n) at a minimum cost while satisfying the demand at all destinations. In this thesis, we shall find the total amount of the products to be supplied specifically club beer from each source to meet the demand at each destination in such a way as to minimize the transportation cost.

1.2 Statement of the problem

Quantitative analysis which is the process determining the value of a security by examining its numerical measurable characteristics such as revenues, earnings, margins and market shares is a powerful tool for evaluating investments or it is the process of presenting and interpreting numerical data.

A most important and successful way of applying quantitative analysis to solving investment/ business problems have been the physical distribution of products, which is normally referred to as transportation problem. The basic idea / objective underlying the transportation problem is to minimize the cost of shipping goods from a number locations / sources to a number of destinations / warehouses so that the needs of each arrival area are met and every

factory / plant/ source operates within capacity. Quantitative analysis has however been used for many problems other than the mere distribution of goods.

For some years now, the cost of transporting single commodity from its source has been high since these costs are transferred to the consumer or in some cases shared between the producer and the consumer. This has caused the marginal profits of most companies / industries to reduce drastically. It is therefore often common to see the expenditure of the yearly balance sheet of the company go high due to transportation.

1.3 Objectives of the study

The main objectives of this study are:

(i) To identify the transportation problems of ABL

(ii) To identify what constitute / determines the transportation costs of ABL

(iii) To use a quantitative model to estimate the optimal number of goods to be transported to various destinations at an optimal transportation cost.

(iv) To find out how beneficial knowing the optimal transportation cost will be to the management of ABL

1.4 Methodology

This thesis will make use of a model based on problem information and real data from ABL.

1.4.1 Data Collection Method

Both primary (interview) and secondary data methods shall be made use of. The data of the model shall include:

(i) The level of supply at each source

(ii) The level of demand at each destination and

(iii) The unit transportation cost from each source to each destination.

1.4.2 Analysis methods (Data Analysis)

To begin with, we shall model the data from section (1.5.1) as a linear programming problem. Qualitative manager for windows (QMW) software will be used to obtain the routes for the transportation and the amount of goods to be transported (shipped) from each source to each destination at an optimal transportation cost. Since a single good from each origin to its destination is being considered, a destination can receive its demand from one or more sources. The aim of the model is to determine the amount to be transported from each source to each destination, such that the total transportation cost is minimized. The basic assumption of the model is that the transportation cost on a given route is directly proportional to the units transported. Since the transportation problem is a linear programming problem, it can be solved using simplex Algorithm but due to its special structure, we shall use the transportation technique to solve the problem

1.5 Justification of the study

All businesses, especially manufacturing industries regardless of whatever it produces, will have to distribute it. This distribution requires the movement of goods / products from one point / place to another, and therefore is involved in transportation.

This means transportation can never be left out and is therefore an essential and relevant part of the manufacturing industry and plays an important role in the economic development of the nation.

Transport operation determines the efficiency of movement of products. The progress in techniques and managerial principles in respect of transportation improves the delivery of goods, service quality, usage of facilities and operation cost.

Furthermore, transportation system permits consumers the ability to make a choice of goods, which would probably not be available.\

A good and proper transportation network makes possible the mobility of people for economic, social, educational or other purposes, while reducing boredom to promote economic, social and political development in the country.

Transportation also brings about links / connections among the several steps that result in the transforming of resources into useful goods for consumers and producers.

Without transportation the movement of goods, services and even people would not have been possible.

Lastly, transportation makes consumers enjoy goods which perhaps due to unfavorable climatic or soil conditions, lack of raw materials, utilities or labour, or high cost of production are not provided in their immediate environment.

A major headache for managers of various companies and distributors of other products is finding the optimal cost of transporting goods / products from many sources to other destinations to maximize profits.

In recent times or era of doing business, all companies in business are working in competition to outperform their competitors and therefore emphasis is placed on building a good customer care in order to win the market place by keeping and growing customers.

If a cost effective way of transporting goods and services is found, it will make goods and services reach their destinations on time to meet customer satisfaction and reliability.

1.6 Limitations of the study

This study is not without shortcomings due to its limitations. Challenges hindering the progress of this study are many.

In writing this project there is the need to interact with people like the distribution managers, transport officers and production officers. Answers given may not be all that correct to be used for the research study whilst others may also put up faces.

These will definitely affect the results of the study. Some of the limitations that would be encountered include:

(i) Limited time available for the extraction of data; managers are not always available in their offices and meeting with them often has to be delayed or rescheduled and this delays data acquisition.

(ii) Limited data; for various reasons not all precise and correct data needed for the study will be given to the researchers some managers see such data to be too confidential to be given to an outsider or a third party.

1.7 Organization of the study

The study is organized into five chapters. Chapter one talks about the introduction of the study. This includes the background of the study, problem statement, significance and objectives of the study, research questions, methodology, limitations and organization of the study.

In chapter two, pertinent literature in the area of transportation shall be reviewed. The profile of ABL and the detailed methodology used in this study shall be presented in chapter three.

Chapter four is solely for data collection and analysis. The final chapter which is chapter five concludes the study with the summary of major findings, conclusion and recommendations.

1.8 Summary

In this chapter we considered how the transportation problem of ABL can be solved.

We also elaborated on the background of the study, statement of the problem, objectives of the study, methodology, justification of the study and limitations of the study.

In the next chapter adequate and relevant literature on transportation shall be reviewed.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter gives adequate and relevant literature on the transportation problem in the brewery industry, modeling of the optimal transportation cost, transportation theory, empirical and theoretical review of the transportation cost in the brewery industry and the importance and the benefits of the optimal transportation cost are presented.

2.1 History of transport

Humans' first means of transport were walking and swimming. The domestication of animals introduces a new way to lay the burden of transport on more powerful creatures, allowing heavier loads to be hauled or humans to ride the animals for higher speed and duration. Inventions such as the wheel and sled helped make animal transport more efficient through the introduction of vehicles. Also water transport, including rowed and sailed vessels, dates back to time in memorial, and were the only efficient way to transport large quantities or over large distance prior to the industrial revolution.

The first forms of road transport were horses, oxen or even humans carry goods over dirt tracks that often followed game trails.

The industrial revolution in the 19th century saw a number of inventions fundamentally change transport. With telegraphy, communication became instant and independent of transport.

The invention of the steam engine, closely followed by its application in rail transport, made land transport independent of human or animal muscles. Both speed and capacity increased rapidly, allowing specialization through manufacturing being located independent of natural resources.

With the development of the combustion engine and the automobile at the turn into the 20^{th} century, road transport became more viable, allowing the introduction of mechanical private transport. The first highways were constructed during the 19^{th} century with macadam's. Later, tarmac and concrete became the dominant paving material. In 1903, the first controllable airplane was invented, and after World War 1, it became a fast way to transport people and express goods over long distance.

After World War 11, the automobile and airlines took higher shares of transport, reducing rail and water to freight and short-haul passenger (Cooper etal; 1998)

2.2 Transportation problems in the beverage industry

Transportation or transport is the movement of people, animals, cattle and goods from one location to another. Modes of transport include rail, air, water, cable, pipeline and space.

The field can be divided into infrastructure, vehicles and operations. Transport is important since it enables trade between peoples which in turn establishes civilizations.

Transport infrastructure consists of the fixed installations necessary for transport and may be roads, railways, airways, waterways, canals and pipelines, and terminals such as airports, railway stations, bus stations, ware houses, trucking terminals, refueling depots (including fueling docks and fuel stations), and seaports. Terminals may be used both for interchange of passengers and cargo for maintenance.

Vehicles traveling on these networks may include automobiles, bicycles, buses, trains, trucks, people, helicopters and aircrafts.

Operations deal with the way vehicles are operated, and the procedures set for this purpose including financing, legalities and policies. In the transport industry, operations and ownership of infrastructure can be either public or private, depending on the country and mode.

Passenger transport may be public, where operations provide scheduled services, or private.

Freight transport has become focused on containerization although bulk transport is used for large volumes of durable items. Transport plays an important part in economic growth and globalization but most types cause air pollution and use large amounts of land, while it is heavily subsided by governments, good planning of transport is essential to make traffic flow, and restrain urban sprawl. (http://en Wikipedia.org/wiki/transport)

The impact of transportation can be seen both at the levels of economic, planning and environment.

With regards to its impact economically, transport is a key to specialization allowing production and consumption of products to occur at different locations. Transport has throughout history been a spur to expansion; better transport allows trade and great spread of people. Economic growth has always been dependent on increasing the capacity and rationality of transport (Stop ford, 1997). But the infrastructure and operation has a great impact on the land and is the largest drainer of energy, making transport sustainability a major issue.

Transport planning allows for high utilization and less impact regarding new infrastructure. Using models of transport forecasting, planners are able to predict future transport patterns. On the operative level, logistics allows owners of cargo to plan transport as part of the supply chain. Transport as a field is studied through transport economics, the backbone for the creation of regulation policy by authorities.

Transport engineering, a sub-discipline of civil engineering, and must take into account trip generation, trip distribution, mode choice and rout assignment, while the operative level is handled through traffic engineering. (Southern, 2006)

Because of the negative impacts made, transport often becomes the subject of controversy related to choice of mode, as well as increased capacity. Automotive transport can be seen as a tragedy of the commons, where the flexibility and comfort for the individual deteriorate the natural and urban environment for all. (Hardin, 1968)

Transport is a major use of energy and burns most of the world's petroleum. This creates air pollution, including nitrous oxides and particulates, and is significant contribution to global warming through emission of carbon dioxide for which transport is the fastest growing emission sector. (Fuglestvet et al; 2007)

2.3 What constitutes/determinants of transportation cost

The food industry faces numerous marketing decisions. Money can be invested in brand building (through advertising and other forms of promotion) to increase their quantities demanded or the price consumers are willing to pay for a product. ABL, for example spends a great deal of money both on perfecting its formula and on promoting the brand. This allows beer to charge more for its products than can makers of regional and smaller brands.

Manufactures may be able to leverage their existing brand names by developing new product lines. For example, Heinz started out as a brand for pickles but branched out into ketch up. Some brand extensions may involve a risk of damage to the original brand if the quality is not good enough.

Manufacturers that have invested a great deal of money in brands may have developed a certain level of consumer brand loyalty that is a tendency for consumers to continue to buy a preferred brand even when an attractive offer is made by competitors. For loyalty to be present, it is not enough to merely observe that the consumer buys the same brand consistently .The consumer, to be brand loyal, must be able to actively resist promotional efforts by competitors. A brand loyal consumer will continue to buy the preferred brand even if a competing product is improved, offers a price promotion or premium or receives preferred display space. Brand loyalty is, of course, a matter of degree. Generally marketers and manufacturers often put together four things that are product, price, distribution and promotion to determine the transportation cost.

Costs come both in fixed and variable categories. Fixed costs are costs that are not affected by the quantity produced. The mortgage on a farm costs the same regardless of how much is planted, and the loan payments on manufacturing equipment are the same regardless of how much it is used.

Variable costs, in contrast, depend on the quantity produced. If a farmer produces less wheat, he or she will need to buy less seed.

Some costs are in a gray area. Labor costs may or may not go down with decreased production especially in the short run. Because fixed costs cannot be changed in the short run, firms may find it optimal to produce a product even though it will lose money. If variable costs, but not fixed costs, are covered, the firm will loss more by not producing (http://www. consumer psychologist icon)

2.3.1 Conditions Affecting the Transportation Cost in the Brewery Industry

Among the most significant conditions affecting transport costs and thus transport rates are:

(i) Geography

(ii) Economies of scale

(iii) Energy

(iv) Trade imbalances / International Trade

(v) Infrastructure

(vi) Mode

(vii) Competition and regulation

(viii) Surcharges

Geography

Its impacts mainly involve distance and accessibility. Distance is commonly the most basic condition affecting transport costs.

The more it is difficult to trade space for a cost, the more the friction of distance is important. It can be expressed in terms of length, time, economic costs or the amount of energy used. It varies greatly according to the type of transportation mode involved and the efficiency of specific transport routes. Landlocked countries tend to have higher transport costs, often twice as much, as they do not have direct access to maritime transportation.

Martinez-Zarzoso and Nowak-Lehmann (2006) analyzed the determinants of maritime and road transport cost for Spanish exports to Poland and Turkey and investigated the different effects of these costs on international trade.

The authors investigated the extent to which maritime and road transport costs depend on different factors such as unit values, distances, transport condition, service structures, and service quality. The authors analyzed the relative importance of road and maritime transport cost as determinants of trade flows. The data on transport cost were drawn from a new database compiled from primary data sources. The main results of this investigation identified the central variables influencing road and maritime transportation costs: for both modes, transport conditions are strong determinants, whereas efficiency and service quality are more important for maritime transport costs, and geographical distance was more important for road transport. Road and maritime transport cost were important explanatory factor of experts and they seemed to deter trade to a greater extent than road or maritime transport time when considered endogenously determined.

The greater the distance between two markets the higher the expected transport cost for their trade. Using shipping company quotes for the cost of transporting a standard container from Baltimore (USA) to selected worldwide destinations, LV(2000) find an extra 1000km raises transport costs by $380 (or 8 percent for a median shipment). Moreover, breaking the journey into an overland and a sea component, an extra 1000 km by sea raises costs by only $190 while the same distance by land raises costs by $1,380-4 and 30 percent of a median shipment respectively. (Bergstrand 1985)

Economies of scale

Another condition affecting transport costs is related to economies of scale or the possibilities to apply them as the larger quantities transported, the lower the unit cost. Bulk commodities such as energy (oil, coal), minerals and grains are highly suitable to obtain lower unit transport costs if they are transported in large tanker ship and quantities. For instance, moving a barrel of oil over 4,000km would cost $1 on a 150,000 deadweight tons, $3 on 50,000 deadweight tons tanker ship. A similar trend also applies to container shipping with larger containerships involving lower unit costs (Rodrigue, J-P et al 2009).

Sass (2005) analyzed unique set of firm – level data on nearly 400 beer distributors in the United States. The impacts of economies of scale and restrictions on distributor promotional activities on the use of exclusive dealing were measured as well as effects of exclusivity on costs, prices and output .The result support the view that exclusive dealing serves to minimize manufacturer-dealer incentive conflicts and enhances social welfare. A home-market effects test using a difference in difference gravity specification was done by Hanson and Xiang (2002). The home-market effect is the tendency for large countries to be net exporters of goods with high transport cost and strong scale economies.

They predicted by models of trade based on increasing returns to scale but not by models of trade based on comparative advantage. The authors selected pairs of exporting countries that prolonged to a common preferential trade area and examined their exports of goods with high transport costs and strong scale economies relative to their exports of goods with low transport costs and weak scale economies. The authors found that home- market effects exist and that the nature of these effects depends on industry transport costs. For industries with very high transport costs, it was national market size that determines national exports. For industries with moderately high transport costs, it was neighborhood market size that matters.

All road transport modes have limited potential to achieve economies of scale. This is due to size and weight constraints imposed by governments and also by the technical and economic limits of engines. In most jurisdictions, trucks and buses have specific weight and length restrictions which are imposed for safety reasons. In addition, there are serious limits on the traction capacities of cars, buses and trucks because of the considerable increases in energy consumption that accompany increases, in the vehicles weight. For these reasons, the carrying capacities of individual road vehicles are limited (http://www peoplehofstra)

International Trade / Trade Imbalances

The scale, volume and efficiency of international trade have all continued to increase, since the 1970s. As such, space / time convergence was an ongoing process that implied wider market coverage could be accessed with a lower amount of time. It has become increasingly possible to trade between parts of the world that previously had limited access to international transportation systems. Further, the division and the fragmentation of production that went along with these processes also expanded trade (Rodrigue, J-Pet al (2009).

Imbalances between import and export have impacts on transportation cost. This is especially the case for container transportation since trade imbalances imply the repositioning of empty containers that have to be taken into account in the total transport cost. Consequently, if a trade balance is strongly negative (more imports than exports), transport cost for imports tend to be higher than for exports. Significant transport rate imbalances have emerged along major trade routes. The same condition applies at the national and local levels where freight flows are often unidirectional, implying empty movements. (UNCTAD, Review of Maritime Transport)

Trade composition additionally helps to explain transport costs across countries. First of all, due to the insurance component of transport costs, products with higher unit value have higher charge per unit of weight. On average, insurance fees are around 2% of the traded value and represent around 15 percent of total maritime charges. Therefore, higher value-added exporting countries should have higher charge per unit weight to this insurance component. On the other hand, some products require special transport features and therefore have different freight rates. (Micro, 2002)

Directional imbalance in trade between countries implies that many carriers are forced to hale empty containers of their return trips. As a result, either exports or imports become more expensive.

Furchsluger (2000a) shows that this phenomenon is observed in the bilateral trade between US and Caribbean. In 1998, for instance, 72 percent of containers sent from the Caribbean to the US were empty. This excess of supply in the northbound route implied that a US exporter paid 83 percent more than a US importer for the same type of merchandise between Miami and Port of Spain (Trinidad and Tobago). Similar phenomenon occur in the Asian - US and Asian - European trade routes, where excess of supply meant that Asian exporters end up to

Paving more than 50 percent in extra transport cost compared to suppliers in the US and Europe. (McConville, 1999)

Rietveld et al., (2010) studied the effect of an imbalance in trade flows on transport prices using micro - data on trips made by carriers in the inland waterway network in North-west Europe. The authors found that imbalances in trade flows have substantial effects on transport prices and estimated that a one standard deviation increase in the regions trade imbalance (the ratio of export and import cargo flows) increases the transport price per ton of trips departing from this region by about seven percent (7%).

A model of bilateral trade balance that captures the effects of all factors influencing trade balance has suggested by elasticity, absorption, and monitoring approaches and the popular gravity model with some extensions was developed by Hossian and Khan (2010). The authors postulated that the relative factors determined the trading pattern, and hence the trade balance of a country in bilateral trade with partners while in the earlier models, absolute factors determine the trade balance. Using standard data techniques, the model was tested empirically and the results showed significant effects of all the relative factors on the bilateral trade balance of Bangladesh in trading with her partners.

Transportation providers utilize resources to make possible the physical movement of the goods, and they must recover the cost of providing this service - transportation cost. To be more specific, "transportation cost includes the rates, minimum weights, loading and unloading facilities, packaging and blocking, damage in transit, and special services available from a carrier - for example, stopping in transit" (Coyle, et al., 2003, p. 342)

Since it is unavoidable the existence of the transportation cost within the international trade atmosphere, several studies have focused on describing the inherent relationship between both of them, because even though "transport costs incurred on traded goods are only one of

the direct costs associated with distance, they are perhaps the one that is readily observable" (Henderson et al., 2001)

Finger and Yeats (1976) affirm that transportation cost "… tends to protect domestic producers from foreign competition – as do such artificial barriers as import quotas, tariffs, etc." Actually

"… transport costs, like tariffs, influence the magnitudes of trade flows, and types of goods exchanged internationally" (Yeats, 1977, P. 7). Moreover, "transport costs pose obstacles to the movement of goods and services so they have important implications for the way a trading world economy is affected" (Cukrowski and Fischer, 2000 pp. 311-312)

Infrastructure

The efficiency and capacity of transport modes and terminals has a direct impact on transport costs. Poor infrastructures imply higher transport costs, delays and negative economic consequences. More developed transport systems tend to have lower transport costs since they are reliable and can handle more movement. (Rodrigue, J-P et-al., 2009).

The quality of onshore infrastructure is an important condition affecting transport. LV (2009) finds that it accounts for 40 percent of predicted transport costs for coastal countries and up to 60 percent for landlocked ones.

If a country with a relative poor infrastructure, say at the 75^{th} percentile in an international ranking, is able to upgrade to the 25^{th} percentile, it will be able to reduce transport costs by between 30 to 50 percent (Micco, 2002). Combes and Lafourcade (2004) developed a methodology to accurately compute transport costs. Based on the real transport network, their measure encompasses the characteristics of infrastructure, vehicle and energy used, as well as labour, insurance, tax and general charges borne by transport carriers.

Micro and Serebrisky (2004) quantified the effects on infrastructure, regulatory quality and liberalization of air cargo markets on transport costs. During the 1990s, the US implemented a series of open skies agreements, which have provided a unique opportunity to access the effect on prices of change in the competition regime. The authors found that infrastructure, quality of regulation and competition matter and that an improvement in airport infrastructure from the 25th to 75th percentiles reduces the air transport costs by fifteen (15) percent. A similar improvement in the quality of regulation reduced air transport costs by 14 percent. In addition, open skies agreements reduced air transport costs by eight (8) percent.

Loree and Guisinger (1995) among others argued that good infrastructure is a necessary condition for foreign investors to operate successfully; also poor infrastructure or unavailable public input increase costs for firms. A free way is faster than a washed out dirt road, e-mail is faster than the post office, and time is money. Thus to the extent that the public input is non-excludable and congestible, it will lower the costs of doing business for multinational and indigenous firms alike. Availability of crucial infrastructure, such as roads, highways, ports, communication networks, and electricity should increase productivity and thereby attract higher levels of Foreign Direct Investment (FDI). As Wei et al., (2000) said "a location with good infrastructure is more attractive than the others" (http://www.uneca.org)

Mode

Different modes are characterized by different transport costs, since each has its own capacity limitations and operational conditions. When two or more modes are directly competing for the same market, the outcome often results in lower transport cost. Containerized transportation permitted a significant reduction in freight transport rates around the world (http://peoplehofstra.edu/geotrans).

Cunningham and Kettlewood (1975), made an analysis of the influence of the supplier's image on buyer behavior in the British rail industry. The companies of sample were manufacturing companies in Scotland. The outcome of the study showed that the main qualitative variables influencing patronage decisions were the availability of the vehicles, the reliability of the delivery and the ability to load and unload at own convenience.

Gilmour, 1976 presented a study conducted in Australia, on the user's preferences on the Melbourne - Sydney services, trying to investigate the factors that were important in the mode choice. Through a cluster analysis the author concluded that direct transportation costs are, among others, not the most important determinants for freight shippers. More relevant elements are the possibility to control shipment, the availability of the required equipment and the reliability.

McGinnis (1979) developed a field study with a sample of 351 shippers in the U.S.A. considering eight topics which were assumed to be relevant in influencing their choice of transport. The eight variables were the following:

(i) Freight rates

(ii) Speed

(iii) Reliability

(iv) Loss and damage

(v) Inventories

(vi) Company policy

(vii) Shipper market conditions

(viii) Influence of the shipper's customers

The respondent had to state the degree of importance on a 5 point scale for 30 statements associated with the eight attributes. Applying a factor analysis McGinnis obtained seven main

Factors, the three most important of which were the ones related to speed and reliability, freight rates and loss and damages.

Burg and Daley (1985) also made an analysis of the mode selection process and marketing impacts on shippers and carriers within shallow - draft barge transport in U. S. A. The results showed that shippers and carriers had different preferences, namely shippers placed more relevance on non – transportation cost factors, and the main element was the satisfaction of the customers, followed by transit time and freight charges.

The application of content analysis developed by Cullinane and Toy (2000) takes into consideration 75 papers dealing with route / mode choice literature, mostly for western production. This typology of analysis, developed in various forms, led the authors to report on the most often considered factor categories in freight route / mode choice literature, to rank those attributes. The first five categories, in order are cost/price/rate, speed, transit time, characteristics of the goods and service.

The list of the criteria considered the literature taken into consideration is based on 19 criteria and out of them six are considered relevant in most of the papers.

The ranking elaborated according to relevance that was expressed in the papers, is showing the following:

(i) Reliability and transit time

(ii) Freight rate and loss/damage

(iii)Customer services

(iv)Load availability

(v) Frequency, flexibility and track and trace

The outcome of the review presented relatively homogeneous results. Some of the criteria had the same ranking, e.g. reliability and transit time that are the most important elements considered in the whole literature examined (http://www.sietitalia.org.)

Girija and Chaudhuri (2006) found out that since the 1970s, the US beer industry had been hit by the rising costs of preparation and preservation of beer and the shifting preferences of consumers towards low-cost beverages like wines, and spirits. Further in the 1980s, increasing health concern among consumers transformed the US beer industry as traditional beers like ales and lagers were replaced by light lager beers and other health drinks. Under such circumstances, Anheuser Bush, the leading brewer in the US, started losing market share to other big brands like SAB Miller and Coors, small-scale local breweries and imported brands like Heineken. To fend off competition, the company launched a series of new products, acquired new brands and entered into partnerships with other breweries to increase its market share.

Competition and Regulation

Concerns the complex competitive and regulatory environment in which transportation takes place. Transport services taking place over highly competitive segments tend to be of lower cost than on segments with limited competition (oligopoly or monopoly).

International competition has favored concentration in many segments of the transport industry, namely maritime and air modes.

Regulations such as tariffs, sabotage laws, labour, security and safety impose additional transport costs, particularly in developing countries (Rodrigue, J - P et al., 2009)

Policies to regulate transport may have different impacts in a competitive market and a market with a dominant producer. The OPEC cartel dominates the oil market which can hardly be considered competitive while OPEC exhibits market power. (Berg et al., 1997a; Alhajii, 2004)

Most studies on regulations in the transportation sector are demand-side analyses (assuming fixed producer prices) that use a utility function as the starting point to calculate optimal fuel taxes (Parry and Small, 2005), measure welfare effects of fuel economy regulations (Fischer et al., 2007) or calculate costs of different regulations to meet certain levels of gasoline consumption (http://www.rff.org)

To sum up the quantity effects in competitive and monopoly markets, the effects of regulations become somewhat more ambiguous with market power. While both a fuel tax and an increased biofuel share will definitely reduce oil demand in a competitive market, the fuel tax is the only instrument studied that has an ambiguous negative effect on oil demand in a monopoly market. But in most realistic cases, the analysis suggests that oil consumption will fall irrespective of policy instrument and market setting studied above. Moreover, it is difficult to state in general terms whether the quantity reductions are largest in a competitive or a monopoly market. (http://www.rff.org)

Surcharges

Surcharges refer to an array of fees, often set in an arbitrary fashion, to reflect temporary conditions that may impact on costs assumed by the transporter. The most common are fuel surcharges, security fees, geopolitical risks premiums and additional baggage fees.

Research on mental accounting (how consumers perceive expenditures) indicates that price impacts are affected by factors such as how prices compare with what is considered normal and good value, whether a financial incentive is presented as a discount or a surcharge, and the frequency of fee collection. (http://www.vtpi.org)

Consumers tend to measure prices with respect to what they perceive as their endowment (what they consider is theirs), and place a greater value on losses than on gains. Some studies indicate that losses from an original endowment are valued at 2.25 times gains.(Thaler,1999).

For example, a typical motorist could be expected to respond 2.25 times as much to a new parking fee (they pay more if they use a parking space) than a parking cash out incentive (they receive a rebate for reducing their use of parking spaces) of the same amount (Shoup, 1997).

2.4 The Transportation Theory and Model

In mathematics and economics, transportation theory is a name given to the study of optimal transportation and allocation of resources.

The problem was formalized by the French mathematician Gaspard Monger in 1781. In the 1920s, Tolstoi was one of the first to study the “Transportation problem” mathematically. In 1930, in the collection “Transportation planning volume / for the National Commissariat of Transportation of the Soviet Union”, he published a paper “Methods of Finding the Minimal Kilometrage in Cargo-transportation in space”.

Major advances were made in the field during World War II by the Soviet / Russian mathematician and economist Leonid Kantorovich. Consequently, the problem as it is stated is sometimes known as the Monge-Kantorovich transportation problem.

Leung et al., (1990) develop an optimization based approach for a point –point route planning that arises in many large –scale delivery. Systems such as communication, rail, mail and package delivery. In these settings, a firm, which must ship goods between many origin and destination pairs on a network, needs to specify a route for each origin – destination pair so as to minimize transportation costs.

They developed a mixed multi – commodity flow formulation of the route planning problem, which contains sixteen million 0-1 variables, which is beyond the capacity of general IP code. The problem was decomposed into two smaller sub-problems, each amenable to solution by a combination of optimization and heuristic techniques. They adopted solution methods based on Langrarian relaxation for each sub- problem.

Saumis et al; (1991) considered a problem of preparing a minimum cost transportation plan by simultaneously solving the following two sub-problems: first the assignment of units available at a series of origins to satisfy demand at a series of destinations and second, the design of vehicle tours to transport these units, when the vehicle has to be brought back to their departure point. The original cost minimization mathematical model was constructed, which is converted into a relaxed total distance optimization, then finally vehicle problem, and an empty vehicle problem.

In this paper entitled 'Logistic costs and the location of the firm: a one dimensional comparative static approach" McCann (1996) argued that the total costs of distance are much greater than simply transportation costs. The reason is that transportation costs are only one component of total logistics costs which also include inventory holding and purchasing costs, and these logistics cost can be shown to be directly related to haulage distance. Further, he showed that the inter regional mobility of a firm will depend on the price of the goods being shipped Jayamaram (1998) formulated a mixed Integer programming model that locked into relationship between inventory, location of facilities and transportation issues in a distribution network design. The formulation involves minimizing the costs of products from open plants to open warehouses and costs to deliver the products from warehouse to customer outlets.

Kenneth and Zapata (1992) presented an approach to space transportation operations cost modeling which synergistically combined knowledge capture with data. The functioning model derived from the approach was described. As with any model, the goal is to gain insights into systems which do not yet exist. In this case, advanced re - usable launch vehicle

concepts. These insights include the interaction of a launch vehicle with its ground infrastructure, hereafter referred to as the spaceport. These interactions include the need, or not, for multiple facilities and ground support equipment costs resulting from acquiring facilities.

Gupta (1992) examined an inventory model where transportation costs were considered explicitly. He found out that it was buyer who must bear the transportation cost of the goods purchased from the supplier. Such costs were either assumed to be fixed, and were therefore included in the ordering cost or variable and included in the item cost, in most realistic situations it was observed that a fixed cost was incurred for a transport mode such as a truck or wagon irrespective of the quantity loaded. No matter the size of the lot, it would always require an integer number of transport modes. Therefore the transportation cost becomes a discrete function. The author developed a lot – size model with discrete transportation costs and presented a simple algorithm for the optimal lot – size.

The transport sector in Botswana has played an important role in economic growth in the 23 years following independence.

The country has been fortunate in discovering natural resources to finance economic developments, and sound policies have ensured that the transport sector grew at an affordable pace commensurate with demands for services. The system of national planning and project appraisals, major historic developments in transport, and policies that have evolved to encourage future growth were presented by Lionjanga and Raman (1990).

2.5 Theoretical Review of Transportation Problem

Kitamura (2009) presented a review of the theoretical and empirical salt in the literature that shed light on the effect of added transportation capacity. Tentative finding include the following : Using existing origin-destination data appears to be a very cost –effective and expeditious approach to addressing the capacity issue , but it can better used with more elaborate statistical method to test behavioral theories. There is no empirical indication that added capacity generates a significant volume of induced traffic. The standard sequential procedure is capable in principle, of forecasting diverted, transferred, and shifted traffic, although actual practice may be less than ideal. Abbreviated application of the procedure, unwarranted attempts to transfer models and extrapolation of the models to inapplicable options are unfortunately present. A better understanding of trip timing decisions and trip chaining behavior is needed. Impacts on car ownership, residential and job location choice, and land use need to be better understood and incorporated into the forecasting procedure. More widespread use of panel surveys is encouraged.

Pollack and Noland (2002) reviewed both the theory and the empirical results of several projects that have estimated coefficients on various measures of variability using stated preference technique. Gaps in the understanding of these issues were identified and discussed by the authors.

2.6 Empirical Review of Transportation Problem in the Beverage Industry

Sharma and Sharma (2003) presented a new procedure to solve the dual of well – known incapacity transportation problem. This is expected to enhance the performance of dual based optimizing, algorithms for solving the transportation problem.

Wie et al, (2005) development on analytic framework for evaluating urban integrated transport policies, including strategies of investment, pricing, management and regulation. In particular, to deal with the difficulty of too many policy combinations, the authors employed genetic algorithms to search for the optimal strategy combination for integrated transport policy. The authors proposed a model and used it to analyze the relationships between quantified objectives, policy combinations, and assessment performances. The results provided a reference to decision makers when drafting urban integrated transport policies.

Data (2000) evaluated the current literature on the use of operational management (OM) in solving the transportation problems in the developing countries. The review was a result of several months of searching through a wide range of journals and publications. The author classified his study into three broad groups: a) Planning and Evaluation, b) Distribution and Location and c) Scheduling and Routing. Finally a research agenda for the future in this important area is outlined.

The continuum modeling approach to transportation models is now gaining much attention because of its advantages in dealing with dense – network models, macroscopic problems and initial phase planning. Wang and Ho (2006) provided a comprehensive review of the development and applications of the two – dimensional continuum modeling approach. The theoretical development and models with specific or arbitrary region configurations are first discussed, and then the applications of the continuum modeling approach to the determination of facility location, route choice, pedestrian flow, and policy and socio - economical analysis were reviewed by Wong and Ho (2006). Finally, same prospective directions for future research are proposed. (www.sciencedirect.com/science). The full public, public and private, monetary and non-monetary, intended and non – intended costs of transportation systems have been the subject of numerous studies, both in Europe and the U.S.A. A paper has been presented that reviewed some key conceptual and theoretical Issues in the identification and measurement of transportation costs and benefits. The authors identified the following three perspectives: Promoting economic efficiency, comparing alternative states of the world, and evaluating questions of equity. Each implies a different paradigm and requires different methods of analysis where each perspective was briefly described and identified unresolved questions and clarified critical areas in need of further work. (http:/trid.tr b.org/view.aspx?id=717677) begin

Empirical studies based on observation of behavior produce detailed and reliable results; these however, are valid only for existing situations and are therefore not suited for assessment of novel yet untested policies. In addition it is usually not possible to associate the observed changes of behavior unequivocally with specific causes, because in reality several determining factors change at the same time. (Hensher A. &Button. K. 2004)

2.7 Benefits of Optimal Transportation Cost

Transportation has tremendous economic, social and environmental impact. It affects our economic productivity, what we consume, our social relations, and the quality of our environment.

It is therefore important to optimize our transportation system to minimize total costs and maximize total benefits.

Transporting is required in the whole production procedures, from manufacturing to delivery to the final consumers and returns. Only a good co – ordination between two components would bring the benefit to a maximum.

Michael et al., (2005) define the role of transportation in logistics for the reference of further improvement. The authors undertake a research to assist logistic managers, research and transportation planners to define and comprehend the basic use of logistic and its various applications and the relationship between logistics and transportation.

Eibl et al., (1994) presented an in – depth case study of the practical experience of applying interruptive vehicle routine and scheduling software at a major brewing company in the United Kingdom (UK). The authors illustrated the use of the software at all levels of transport planning and addresses strategic, tactical and operational issues; comprises a review of the

software over all implementation and its consequences within the organization. Special attention was given to the critical analysis of both quantitative and qualitative benefit, as well as organizational problems arising from the use of such software.

Sass (2005) analyzed a unique set of firm-level data on nearly four hundred (400) beer distributers in the United States.

The impact of economies of scale and restrictions on distributers' promotional activities on the exclusive dealings were measured as well as the effect of exclusivity on cost, prices, and output. The author supported the view that exclusive dealing serves to minimize manufacture – dealer incentive conflicts and enhance social welfare.

Cernat (2001) finds empirical evidence to support that African Free Trade Areas (FTAs) and customs unions stimulate trade not only within the continent but also with non African countries. Similarly, Ebadaw; (1997) argue that the expanded sub regional markets that characteristically accompany the formation of African regional trade blocks could generate sufficient scale economies that could result in the much-desired production complementarities and diversity among member state of such union. In a similar analysis, Lewis et al.(1999) and Evans(1998) found that Southern African regional schemes generated significant, positive net welfare effects. (www.uneca.org). Calantone (1992) estimated the gains associated with a policy of removing Canadian inter provincial barriers to trade in beer. An historical, institutional and political introduction clarified the problem context and famed the policy conclusions the study offered. The key strategic competitive factors in Canadian brewing were listed and evaluated. A mathematical programming model of the brewing industry was described which used constraints to create four cases which represented alternative regulatory regimes. The relaxation of interprovincial sales barrier constraints

characterizes the free market cases. Optimal decisions for a dominant competitor were computed for each case. Results suggested that significant returns to regulatory reform could be expected. These results have distinct policy implications, since current national costs of regulatory compliance with the interprovincial sales restrictions alone was estimated to be in excess of 100 million dollars per year. When combined with the costs of other regulatory controls, the overall regulatory compliance costs were in excess of 150 million dollars per year for this industry.

Annually, breweries in the United States spend over $200 million on energy. Energy consumption is equal to 3-8% of the production costs of beer, making energy efficiency improvement an important way to reduce cost, especially in times of high energy use, Galitsky et al., (2003) examined energy efficiency opportunities available for breweries and provided specific primary energy savings for each energy efficiency measure based on case studies that have implemented the measures as well as references to technical literature. If available, the authors also listed typical payback periods and suggested that given available technology, there are still opportunities to reduce energy consumption cost effectively in the brewery industry. Brewers value highly the quality, taste and drinkability of their beer. Brewing companies have and are expected to continue to spend capital on cost – effective energy conservation measures that meet these quality, taste and drinkability requirements. For individual plants, further research on the economics of the measures, as well as their applicability to different brewing practices, is needed to access implementation of selected technologies.

Gurdon and Xiang (2004) developed a monopolistic competition model of a trade with many industries to examine how home-market effects vary with industry characteristics. Industries with high transport costs and more differentiated products tend to be more concentrated in large countries than industries with low transport costs and less differentiated products. The authors tested this prediction using a difference –in –difference gravity specifications that controls for import tariffs, importing country remoteness, home bias in demand, and the tendency for large countries to export more of all goods. They found strong evidence of home-market effects whose intensity varied across industries in a manner consistent with theory.

Economic theory suggest that in addition to the direct transport cost savings from road improvement, some indirect "reorganization" or "restructuring" benefits should also be expected. (Mohring and Williamson, 1969).

Nelson (2004) reviewed major events, data trends and research for each of three issues:

The importance of advertising and product differentiation for structural change in the brewing industry

The manner and extent to which brewers can strategically alter market shares using advertising and

The social costs of beer advertising and marketing, including advertising bans, targeting of underage youth, and recent changes in the three-tier system of alcohol distribution. Major legal decisions pertaining to commercial speech and other regulations were also discussed.

Salmon and Koksalan (2003) discussed their experience in using a case study of location and distribution decisions in undergraduate and MBA level management Science and Operations Research courses.

The Anadolu Efes case introduces a multi-period strategic planning problem that requires the optimization of brewery location and capacity expansion.

Support for the notion that road improvement s might help remote areas to grow comes from Helpman (1998), who shows that when transport costs falls, firms move away from cities save on rents. However, Kingman (1991) shows the opposite reducing transport costs cause agglomeration.

As transport costs reduce if all firms should respond by substituting within the production and distribution process so as to arrive at a more transport-intensive, but lower cost solution. The restructuring of the brewery into an operation with large plants is often attributed to at least in part, to improvements in the road network. A number of restructuring responses to strategic road investment may be listed:

- Centralization of manufacturing or production
- Improvement in service quality (24 hour delivery etc)

- Changes in distribution methods (e.g. Satellite distribution)
- Increase in market areas served by regional firms
- Changes in inter-depot boundaries
- Concentration of distribution into fewer depots

This list suggests that indirect benefits are likely to be some mixture of economies of scale in production or warehousing, inventory savings and added value to products.

It is claim a number of studies undertaken in the past into the benefits from road network improvement played a part in the decline of road haulage rates between 1974 and 1984 of 27% (Turner; 1987).

Benefits gained in terms of larger trading areas have been revealed by studies of the major estuary crossings, such as the Server and Humber Bridges (Cleary and Thomas 1973) (Mackie and Simon; 1986).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter deals with the methodology of the study. To begin with, the profile of ABL shall be looked at including its vision, mission and values then some terms relating to sampling techniques shall be explained

3.1 Profile of Accra Brewery Limited (ABL)

Accra Brewery Limited (ABL), originally known as Overseas Breweries Limited, was registered on 30th June, 1931, for the purpose of establishing a brewing industry in the then Gold Coast. It was the first brewing industry in the whole of West Africa and, indeed, the first non-traditional manufacturing industry in the Gold Coast. On 1st April, 1975, the assets of the former Overseas Breweries Ltd. were taken over by the locally registered Accra Brewery Limited to pave the way for Ghanaian participation in the business. The company was provisionally listed on the Ghana Stock Exchange on November 12, 1990 and formally on November 20, 1991.

In 1997, SABMiller plc (then South African Breweries) acquired controlling shares in the company.

ABL has one billion authorized shares of which 249,446,664 are issued making its stated capital GH¢7,332,000.00. It has Overseas Breweries Limited as it major shareholders with about 62.9% of the shares outstanding. Today, ABL is a public company engaged in the manufacture and distribution of beer, sparkling soft drinks and non alcoholic malt beverages.

The managing director of ABL, Mr. Gregory Metcalf has held this position since 1st June 2009.

3.1.1 Location and Logo

ABL can be located in the 1st floor Nasser building 22 Farrar Avenue, Accra, Ghana. The logo of ABL is as seen below.

3.1.2 Vision

To be the most admired company in the Beverage sector by being the:

(i) Investment of choice

(ii) Employer of choice

(iii)Partner of choice

3.1.3 Mission

To own and nurture local and international brands which are the first choice of the consumer.

3.1.4 Values

- Our people are our enduring advantage
- Accountability is dear and personal
- We work and win in teams

- We understand and respect our customers and consumers
- Our reputation is indivisible

3.2 Target Population

The target population refers to the entire group of individuals or objects to which researchers are interested in generalizing the conclusions. The target population usually has varying characteristics and it is also known as the theoretical population.

Usually the initial /basic step taken in developing any sampling design is to clearly define the aggregate of sampling units, namely, the population. Sometimes the structure of the population is so simple such as the number of workers in a factory.

Sometimes, there may also be instances where the make-up of the population is not so simple.

3.2.1 Sampling Design

A sampling design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure researchers would adopt to select units for the sample. It will also indicate the number of units to be included in sample also known as sample size.

Sampling design is determined before data is collected

It also refers to the collection of data from a sample of units that have been selected from the target universe with the intention that they should be representative of that universe.

3.2.2 Sampling

Sampling is the process of selecting units (e.g. people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen.

Sampling is also concerned with the selection of a subset of individuals from within a population to estimate characteristics of the whole population. The three main advantages of sampling are that the cost is lower, data collection is faster and since the data set is smaller, it is possible to ensure homogeneity and to improve the accuracy and quality of the data.

The totality of all members is known as population. The selected part, which is used to ascertain the characteristics of the population, is known as “sample”.

The population size and sample size comprises of the total members of the population and the number included in the sample respectively.

3.2.3 Sample Size

Sample size is simply a subset of the population. The concept of sample arises from the inability of the researchers to test all the individuals or objects in a given population. The sample must be representative of the population from which it was drawn and it must have good size or be adequate to warrant analysis. When a sample is representative, it will be a relatively small piece of the population that mirrors the various patterns and sub-classes of the population. A sample is adequate if it provides an estimator with sufficiently high precision.

It should be noted very well in this context that the higher the precision, the larger the sample size and the higher the cost.

The study uses the linear programming model in the setting up of a model for the transportation model for ABL as well as employing the use of models which incorporate quantitative techniques in the entire frame.

The population involves the use all unit prices and routes taken by the Accra Brewery Limited for its distribution across the country, where costs are obtained with the appropriate routes to their destinations.

3.3 Research Design

A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. It is the conceptual structure within which research is conducted, constitutes blue print for collection, measurement and analysis of data.

3.3.1 Primary and Secondary Data

The researcher used both the quantitative and qualitative method based on the objectives of the research.

Quantitative data were collected from secondary sources – thus someone had to process that information and record it. These included the level of supply from each source, the level of demand of each destination and the unit transportation cost from each source to destination.

On the other hand, qualitative method involved the use of interview guides to collect primary data from the production manager and transport officer. The interviews were conducted to provide data on the problems ABL faces in transporting their products and what are factored in to determine the cost of transportation for their products.

3.3.2 Sampling Method

A non-probability sampling method preferably a purposive sampling was used to gather the data. This is a type of sampling in which a sample is selected in a deliberative and non-random fashion to achieve a certain goal or a judgment sample is obtained according to the discretion of someone who is familiar with the relevant characteristics of the population. Under this method, the researcher deliberately or purposively draws a sample from the population. All members of the population are not given the chance to be selected in the sample. The personnel bias of the investigator has a great chance of entering the sample and if the investigator chooses a sample to give results which favour his view point the entire study may be vitiated.

3.3.3 Data Collection

The researcher employed both primary and secondary data collection methods. The primary data which is data observed or collected directly from first –hand experience. Since it is first hand, it has not been published yet and is more reliable, authentic and objective.

In this study, it represents the data gathered from the interview with the production manager of ABL. The secondary data, is data collected from a source that has already been published in any form, in this study, it represents the unit cost from the sources to its destination across the country and also the demand and supply for the various plants and warehouses respectively.

The primary data was mainly gathered through interview with the production manager and the secondary data from the transport officer.

The questionnaire used as an interview guide to gather the data can be seen (Appendix A)

3.4 Analysis of Data

Data analysis is a process of inspecting, clearing, transforming and modeling data with the goal of highlighting useful information, suggesting conclusions and supporting decision making.

It can also be seen as a body of methods that help to describe facts, detect patterns, develop explanations, and test hypothesis.

In this study quantitative method was used to carry out the analyses of the researcher's data. The qualitative analysis was also incorporated in areas where it was open-ended question to the production manager. Moreover, the transportation model was used to analyze the data from the secondary data.

3.4.1 Analytical framework

A transportation problem basically deals with the problem, which aims to find the best way to fulfill the demand of **n** demand points using the capacities of **m** supply points. The objective in a transportation problem is to fully satisfy the destination requirements within the operating production capacity constraints at the minimum possible cost. Where ever there is a physical movement of goods from one point of manufacture to the final consumers through a variety of channels of distribution (wholesalers, retailers, distributors etc), there is a need to minimize the cost of transportation so as to increase the profit on sales. Transportation problems arise in all such cases as providing assistance to top managers in ascertaining how many units of a particular product should be transported from each supply origin to each demand destinations so that the total prevailing demand for the company's product is satisfied, while at the same time the total transportation costs are minimized.

Sasieni et al., (1959) noted that problems of allocation arise whenever there are a number of activities to perform, but limitations on either the amount of resources or the way they can be spent prevent us from performing each separate activity in the most effective way conceivable. In such situations, we wish to allot the available resources to the activities in a way that will optimize the total effectiveness.

To model the transportation problem of ABL, a quantitative model was set up. The model sought to determine the transportation (shipping) plan of ABL from two sources to ten destinations in Ghana, subject to the required demands at the various destinations and capacities at the sources.

An Initial Basic Feasible Solution (IBFS) is required to be the starting point to solve ABL's transportation problem and this was obtained by the use of Vogel's Approximation Method (VAM) which is an analytical method of solving transportation problems.

Two other methods, the least – cost and northwest – corner rule can also be used to find the IBS of the transportation problem but the quality of the least – cost starting solution is better than that of the North West – corner rule because it yields a smaller value in the same example.

From Amponsah's (2010) lecture notes, the transportation problem deals with a special class of linear programming problems in which the objective is to transport the commodity from the various sources where they are produced to the various ware houses or depots at minimum cost while satisfying all constraints of productive capacity and demands. The cost of shipping a unit of goods from a known origin to a known destination as well as the total supply available at the origin and the total quantity demanded by the destinations are given in the statement of the problem.

The model deals with how to get the minimum – cost plan to transport a commodity from a number of sources (m) to number of destinations (n). The solution algorithm to a transportation problem can be summarized into the following steps:

Step 1: Formulate the problem and set up in a pattern that uses all the products available and satisfies all requirements.

This is called developing an initial basic solution. The transportation problem can be modeled as that similar to linear programming problem formulation. Here the objective function is the total transportation cost and the constraints are the supply and demand available at each source and destination, respectively.

Generally, the mathematical model may be given as follows:

Minimize $Z = \sum C_{ij} X_{ij}$

Subject to:

$X_{ij} \leq S_i$ for i= 1, 2…m (supply)

$X_{ij} \geq D_j$ for j = 1, 2… n (demand)

$X_{ij} \geq 0$

For a feasible solution to exist, it is important that total capacity equals total requirements

Total supply = total demand or $\sum S_i = \sum D_j$

If total supply = total demand, then the problem is said to be balanced transportation problem.

S_i (supply) and D_j (demand) are all positive integers.

Each variable X_{ij} appears in exactly two constraints, one is associated with the origin and the other is associated with the destination.

Putting in the matrix form, the elements of the matrix are either zero (0) or one (1).

Table 3.1: The transportation tableau

SUPPLY

S_1	c_{11}	c_{12}	c_{13}		c_{1n}	a_1
S_2	c_{21}	c_{22}	c_{23}	…	c_{2n}	a_2
S_m	c_{m1}	c_{m2}	c_{m3}	…	c_{mn}	a_m
Demand	D_1	D_2	$D_{3...}$	…	D_n	

Step 2: Obtain an initial basic feasible solution. This Initial Basic Solution (IBS) can be obtained by the following using methods:

(i) North -west Corner Rule

(ii) Least – Cost Method

(iii) Vogel's Approximation Method (VAM)

The solution obtained by any of the above methods must fulfill the following conditions:

(i) The solution must be feasible, meaningful; it must satisfy all the supply and demand constraints. This is called rim condition.

(ii) The number of positive allocations must be equal to (m+n-1), where m is number of rows and n is number of columns.

(iii) The solution that satisfies the above mentioned constraints is called a non-generate basic feasible solution.

Step 3: Test the initial solution for optimality.

The methods of solution to be discussed are variants of the simplex method. They are

(i) The Stepping -Stone Method

(ii) Modified Distribution Method (MODI)

If the solution is optimal, then stop, otherwise, determine a new improved solution.

3.4.2 Initial Basic Feasible Solution (IBFS)

A feasible solution to a transportation problem is basic if and only if the corresponding cells in the transportation table do not contain a loop. A solution is called a basic feasible solution if:

(i) It involves (m+n-1) cells with non- negative allocation (circled).

(ii) There are no circuits among the cells in the solution.

The three common methods used to obtain the initial basic solution differ in "quality" of the starting basic solution they produce and better starting solution.

3.4.3 North-West Corner Method

The following steps are to be followed if one wants to find an Initial Basic Feasible Solution using the Northwest Corner Method:

Step 1: Choose the entry in the upper left hand corner (North-west corner) of the transportation tableau, i.e. the shipment from source 1 to warehouse 1

Step 2: Use this to supply as much of the demand at W_1, as possible. Record the shipment with a circled number in the cell.

Step3: If the supply at S_1 is not used up by the allocation in the circuit use the remaining supply to fill the remaining demands at W_2 ,$W_{3\,...}$ in that order until supply at S_1 is used up. Record all shipments in circles in the appropriate cells.

Step 4: When one supply is used up, go to the next supply and start filling the demands beginning with the first warehouse in that row, where there is still a demand unfilled, recording in circled numbers all allocations.

Even in the case of degeneracy the Northwest corner rule still yield a BFS if it is modified as follows; Having obtained a solution which is not a BFS choose some empty cells and add there the solution with circled zeros in them, so to produce a BFS, that is

(i) The total number of cells with allocations should be m+n-1

(ii) There should be no circuit among the cells of the solution.

3.4.4 Least- Cost Method

The least-cost method identifies the least unit cost in the transportation tableau and allocates as much as possible to its cell without violating any of the supply or demand constraints. The satisfied row or column is then deleted (crossed out). The next least weight cost is identified and as much as possible is allocated to its cell, without violating any of the supply and demand constraints. The satisfied row or column is deleted (crossed out). This procedure is continued until all rows and columns have been deleted

3.4.5 Vogel's Approximation Method (VAM)

To find an initial basic feasible solution using the Vogel's Approximation Method, we go through the following process.

First compute column penalties for each column by identifying the least unit cost and the next least unit in that column and taking either positive difference. This is the column penalty for the column. In a similar way, we may compute the row penalty for each row as the positive difference between the least unit cost and the next least unit cost in that row.

Column penalties are shown below the columns and row penalties are shown to the right of each row.

The method is a variant of the Least-Cost Method and is based on the idea that if for some reason the allocation cannot be made to the least cost cell via row or column then it is made to the next least cost cell in that row or column and the appropriate penalty paid for not being able to make the best allocation. If a tie occurs, use any arbitrary tie breaking choice.

VAM determines an initial basic feasible solution which is very close to the optimal solution.

3.4.6 Illustrative example

VAM is applied to our example.

Consider the transportation problem presented in the following table

DESTINATION

ORIGIN	1	2	3	4	SUPPLY
1	20	22	17	4	120
2	24	37	9	7	70
3	32	37	20	15	50
DEMAND	60	40	30	110	240

Solution

Calculating penalty for table 1

17-4=13, 9-7=2, 20-15=5 (Row penalties)

24-20=4, 37-22=15, 17-9=8, 7-4=3 (Column penalties)

Table 1

DESTINATION

ORIGIN	1	2	3	4	SUPPLY	PENALTY
1	20	22 (40)	17	4	~~120~~ 80	13
2	24	37	9	7	70	2
3	32	37	20	15	50	5
DEMAND	60	~~40~~	30	110	240	
PENALTY	4	15	8	3		

The highest penalty occurs in the second column. The minimum C_{ij} in this column is C_{12} (i.e., 22). So X_{12}=40 and the second column is eliminated. The new reduced matrix is shown below:

Now again calculate the penalty

Table 2

ORIGIN	**1**	**3**	**4**	**SUPPLY**	**PENALTY**
1	20	17	4 (80)	~~80~~	13
2	24	9	7	70	2
3	32	20	15	50	5
DEMAND	60	30	~~110~~ 30		
PENALTY	4	8	3		

The highest penalty occurs in the first row. The minimum C_{IJ} in this row is C_4 (i.e., 4) So X_{14} =80 and the first row is eliminated. The new reduced matrix is shown below:

Table 3

ORIGIN	**1**	**3**	**4**	**SUPPLY**	**PENALTY**
2	24	$9^{(30)}$	7	70	2
3	32	20	15	50	5
DEMAND	60	~~30~~	30		
PENALTY	8	11	8		

The highest penalty occurs in the second column. The minimum c_{ij} in this column is C_{23} (i.e., 9) So X_{23}=30 and the second column is eliminated. The reduced matrix is given in the following table.

Table 4

ORIGIN	**1**	**4**	**SUPPLY**	**PENALTY**
2	$24^{(10)}$	$7^{(30)}$	~~40~~	17
3	$32^{(50)}$	15	~~50~~	17
DEMAND	~~60~~	~~30~~		
PENALTY	8	8		

The following table shows the computation of penalty for various rows and columns

Final table.

	DESTINATION										
ORIGIN	1	2	3	4	SUPPLY	PENALTY					
1	20	$22^{(40)}$	17	$4^{(80)}$	~~120~~	13	13	-	-	-	-
2	$24^{(10)}$	37	$9^{(30)}$	$7^{(30)}$	~~70~~	2	2	2	17	24	24
3	$32^{(50)}$	37	20	15	~~50~~	5	5	5	17	32	-
DEMAND	~~60~~	~~40~~	~~30~~	~~110~~	240						
	4	15	8	3							
	4	-	8	3							
PENALTY	8	-	11	8							
	8	-	-	8							
	8	-	-	-							
	24	-	-	-							

Initial basic feasible solution 22 x 40 + 4 x 80 + 24 x 10 + 9 x 30 + 7 x 30 + 32x 50 = 3520

3.4.7 Comparison of Methods

Vogel’s Approximation method provides a BFS which is close to optimal or is optimal and thus performs better than the North-west Corner Rule or the Least-Cost Method.

Again, unlike the Northwest Corner Rule, Vogel's Approximation method may lead to an allocation with fewer than m + n – 1 non – empty cells even in the non- degenerate case.

To obtain the right number of cells in the solution, we add enough zero entries to empty cells, avoiding the generation of circuits among the cells in the solution**.**

3.4.8 Improving the Solution to Optimal

The solutions obtained from the three methods discussed above are feasible but not the optimal. We improve them to optimal by employing the following methods:

(i) Stepping- Stone Method

(ii) Modified Distribution Method (MODI). For this study the method we shall use this to improve our solution to optimality is the Modified Distribution Method (MODI) because its currently the most efficient method of solving the transportation problem.

3.4.9 Modified Distribution Method (MODI) or (u-v) Method

The Modified Distribution Method, also known as MODI Method or (u-v) method provides a minimum cost solution to the transportation problem. In the Stepping Stone method, we have to draw as many closed paths as equal to the unoccupied cells for their evaluation. To the contrary, in MODI method, only closed path for the unoccupied cell with highest opportunity cost is drawn. MODI method is an improvement over Stepping Stone method. The method, in outline is:

1. Determine an initial basic feasible solution using any one of the three methods given below :

(i) Northwest Corner Rule

(iii) Least-Cost Method

(iv) Vogel Approximation Method

2. Determine the values of dual variables , U_i and V_j, using $U_i + V_j = C_{ij}$
3. Compute the opportunity cost using $C_{ij} – (U_i + V_j)$
4. Check the sign of each opportunity cost. If the opportunity costs of all the unoccupied cells are either positive or zero, the given solution is the optimal solution. On the other hand, if one more unoccupied cell has negative opportunity cost, the given solution is not an optimal solution and further savings in transportation cost are possible.
5. Select the unoccupied cell with the smallest negative opportunity cost as the cell to be included in the next solution.
6. Draw a closed path or loop for the unoccupied cell selected in the previous step. Please note that the right angle turn in this part is permitted only at occupied cells and at the original unoccupied cell
7. Assign alternate plus and minus signs at the unoccupied cells on the corner points of the closed path with a plus sign at the cell being evaluated.
8. Determine the maximum number of units that should be shipped to this unoccupied cell. The smallest value with a negative position on the closed path indicates he number of units that can be shipped to the entering cell. Now, add this quantity to all the cells on the corner points of the closed path marked with plus signs, and subtract it from the cells marked with minus signs. In this way, an unoccupied cell becomes an occupied cell

9. Repeat the whole procedure until a minimal solution is obtained

3.4.10 Illustrative example

Consider the transportation problem presented in the following table

Distribution Centre

		D1	D2	D3	D4	SUPPLY
PLANT	P1	19	30	50	12	7
	P2	70	30	40	60	10
	P3	40	10	60	20	18
DEMAND		5	8	7	15	

Solving the optimal solution of the above problem.

Solution:

An initial basic feasible solution is obtained by Matrix Minimum Method and is shown in table 1

Table 1

Distribution Centre

		D1	**D2**	**D3**	**D4**	**SUPPLY**
	P1	19	30	50	$12^{(7)}$	7
PLANT	P2	$70^{(3)}$	30	$40^{(7)}$	60	10
	P3	$40^{(2)}$	$10^{(8)}$	60	$20^{(8)}$	18
DEMAND		5	8	7	15	

Initial basic feasible solution

12 x 7 + 70 x 3 + 40 x 2 + 10 x 8 +20 x 8 = 894

Calculating U_i and V_j using $U_i + V_j = C_{ij}$

Substituting $U_1 = 0$, we get

$\mathbf{U_1 + V_4 = C_{14} \rightarrow 0 + V_4 = 12 \text{ or } V_4 = 12}$

$\mathbf{U_3 + V_4 = C_{34} \rightarrow U_3 + 12 = 20 \text{ or } U_3 = 8}$

$\mathbf{U_3 + V_2 = C_{32} \rightarrow 8 + V_2 = 10 \text{ or } V_2 = 2}$

$\mathbf{U_3 + V_1 = C_{31} \rightarrow 8 + V_1 = 40 \text{ or } V_1 = 32}$

$\mathbf{U_2 + V_1 = C_{21} \rightarrow U_2 + 32 = 70 \text{ or } U_2 = 38}$

$\mathbf{U_2 + V_3 = C_{23} \rightarrow 38 + V_3 = 40 \text{ or } V_3 = 2}$

Table 2.

Distribution Centre

		D1	D2	D3	D4	SIPPLY	U_i
PLANT	P1	19	30	50	$12^{(7)}$	7	0
	P2	$70^{(3)}$	30	$40^{(7)}$	60	10	38
	P3	$40^{(2)}$	$10^{(8)}$	60	$20^{(8)}$	18	8
DEMAND		5	8	7	15		
V_j		32	2	2	12		

Calculating opportunity cost using $C_{ij}-(U_i+V_j)$

UNOCCUPIED CELLS	**OPPORTUNITY COST**
(P1 , D1)	$C_{11} – (U_1 + V_1) = 19 – (0 + 32) = -13$
(p1 , D2)	$C_{12} – (U_1 + V_2) = 30 – (0 + 2) = 28$
(P1 , D3)	$C_{13} – (U_1 + V_3) = 50 – (0 + 2) = 48$
(P1 , D2)	$C_{22} – (U_2 + V_4) = 30 – (38 + 2) = - 10$
(P1 , D4)	$C_{14} – (U_2 + V_4) =60 – (38 + 12) = 10$
(P3 , D3)	$C_{33} - (U_3 + V_3) = 60 – (8 + 2) =50$

Table 3

Distribution Centre

		D1	D2	D3	D4	SUPPLY	U_i
PLANT	P1	-13 19	28 3 0	48 50	12^{7}	7	0
	P2	$70^{(3)}$	-10 30	$40^{(7)}$	10 60	10	38
	P3	$40^{(2)}$	10	50 60	$20^{(8)}$	18	8
DEMAND		5	8	7	15		
V_j		32	2	2	12		

Now choose the smallest (most) negative value from opportunity cost (i.e. – 13) and draw a closed path from P1D1. The table shows the closed path.

Table 4

Distribution Centre

		D1	D2	D3	D4	SUPPLY	U_i
PLANT	P1	-13 19	28 30	48 50	$12^{(7)}$ –	7	0
	P2		-10 40		10 60	10	38
	P3	$40^{(2)}$	$10^{(8)}$	50	$20^{(8)}$	18	8
DEMAND	5	8	7	15			
V_j	32	2	2	12			

Choose the smallest value with a negative position on the closed path(ie, 2), it indicates the number of units that can be shipped to the entering cell. Now add this quantity to the cells on the corner points of the closed path marked with plus signs.

In this way, an unoccupied cell becomes an occupied cell.

Now again calculate the values for U_i and V_j and opportunity cost. The resulting matrix is shown below.

Table 5

Distribution Centre

		D1	D2	D3	D4	Supply	U_i
Plant	P1	$19^{(2)}$ +	$\boxed{28}$ 30	$\boxed{61}$ 50	$12^{(5)}$	7	0
	P2	$70^{(3)}$ −	$\boxed{-23}$ 30 +	$40^{(7)}$ −	$\boxed{-3}$ 60	10	5
	P3	$\boxed{13}$ 40	$10^{(8)}$ -	$\boxed{63}$ 60	$20^{(10)}$ +	18	8
Demand		5	8	7	15		
V_j		19	2	-11	12		

Choose the smallest (most) negative value from opportunity cost (i.e., -23). Now draw a closed path from P2D2.

Table 6

Distribution Centre

		D1	D2	D3	D4	Supply	U_i
	P1	+ $19^{(2)}$	28 30	61 50	$12^{(5)}$	7	0
Plant	P2	$70^{(3)}$	-23 30 +	$40^{(7)}$ −	-3 6 0	10	51
	P3	40 13	$10^{(8)}$ −	63 60	$20^{(10)}$ +	18	8
Demand		5	8	7	15		
V_j		19	2	-11	12		

Now again calculate the values for U_i and V_j and opportunity cost.

Table 7

Distribution Centre

		D1	D2	D3	D4	SUPPLY	U_i
PLANT	P1	$19^{(5)}$	28 30	38 50	$12^{(5)}$	7	0
	P2	23 70	$30^{(3)}$	$40^{)}$	20 60	10	28
	P3	13 40		40 60	$20^{(13)}$	18	8
DEMAND		5	8	7	I5		
V_j		19	2	-11	12		

Since all the current opportunity cost are non-negative, this is the

Optimal solution. The optimal transportation cost is:

19 x 5 + 12 x 2 + 30 x 3 + 40 x 7 + 10 x 5 + 20 x 13 = 799

3.5 Mathematical Model for the Transportation Problem

The transportation problem to be solved was put into mathematical form.

The researcher used the computer software (Quantitative Manager for Windows) for the Vogel's Approximation Method to search the Initial Basic Feasible Solution

Objective function: in Z= $\sum_{i=1}^{i=m}\sum_{j=1}^{j=n} C_{ij} X_{ij}$ (3.1)

Subject to $$\sum_{j=1}^{j=n} X_{ij} \leq a_i ; (i = 1, 2, ... m) \quad (3.2)$$

$$\sum_{i=1}^{i=m} X_{ij} \geq d_j (j = 1, 2, ..., n) \quad (3.3)$$

$$X_{ij} \geq 0 (i = 1, 2, ..., m; \ j = 1, 2, .., n) \quad (3.4)$$

The decision variables are the number of units of a single product from the sources to various regions.

Constraint (3.2) stipulates that the amount transported from each source cannot exceed the available supply. Constraint (3.3) stipulates that the amount transported to each warehouse must meet or exceed required demand. The non-negative constraint (3.4) ensures that all amount transported must be non-negative.

The total cost of transportation to each warehouse is computed by multiplying the amount transported by their respective unit cost and summing. The objective of the model is to minimize the total transportation cost.

3.6 Solver Parameters Dialog

To define this problem for Quantitative Manager for Windows (QMW), the cell containing The decision variables, constraints and the objective function must be specified. This is done by choosing the solver command from the tool menu, which causes the solve dialog to appear. The target cell is the cell containing the objective function or the problem to be solved.

3.6.1 Solver Option Dialog

Selecting the ‘‘options’’ button in the solver parameters dialog brings out a solver option dialog box. The current solver version does not determine automatically if the problem is linear or non-linear. To inform the solver that the problem is LP , select ‘‘assume linear model’’ box. This causes simplex solver to be used.

3.6.2 Solving the Simplex Model

Select ‘‘model’’ box and choose the model to be used from the dialog box then click ‘ok’ in the model dialog option, put in the necessary data in the dialog then click ‘ Solve’ on the solver parameter dialog. This causes the simplex solver model used to solve after each iteration. Because an initial basic feasible is not provided, the simplex method begins with an infeasible solution and proceeds to reduce the sum of infeasibilities. Observe this by pressing ‘continue’ after each iteration.

3.7 Summary

In this chapter, the methodology of the study was put forward and explained.

The next chapter presents the data collection and analysis of the study.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.0 Introduction

This chapter captures data collection and analysis of the study.ABL has two main plants that is Accra and Kumasi which are in the Greater Accra and Ashanti regions respectively. The Club beer produced by these plants, are transported in trucks by road to all the 10 regions in Ghana. The average monthly supply of Beer from each source and the monthly demand from each region in Ghana were recorded with the corresponding transportation cost from each source to each region. The data was then modeled as a transportation problem. QMW software was used to solve the problem by first using the VAM to secure an initial basic feasible solution (IBFS) and the Modified Distribution Method was then used to improve the IBFS to optimality.

4.1 Transportation Challenges Faced By ABL

As one of the biggest brewing companies in Ghana, ABL faces some challenges in transportation. Through the researcher's interaction with the transport manager of ABL, there was indication that the following are some of the challenges ABL faces in transporting cartons of beer across the country.

(i) Budgeting constraints

(ii) Traffic congestion

(iii) Accidents

(iv) Lack of mobility and accessibility

(v) Disconnected transportation modes

(vi) Safety and security

(vii) Delays in goods movement

(viii) Lack of information/communication

These challenges listed above from the manager were the challenges that hinder the intra regional distribution of beer from the two sources to the ten destinations within the country for onward distribution to retailers.

4.2 Factors Affecting Transportation Cost

The transport manager further stressed that other general factors affect the transportation of the products, and these costs increase the budgetary constraints of transportation cartons of beer to the regions. These general factors among others were:

(i) Maintenance costs

(ii) Fuel costs

(iii) Haulage costs

(iv) Terminal costs

4.3 Benefits of Knowing Optimal Cost

The benefits of knowing optical cost of transportation commodities/goods cannot be overemphasized. Optimal cost is essential in achieving perspective efficiency in both production and transportation. Enormous benefits are accrued from the knowledge of the benefits of optimal cost, these benefits from the basis for the planning of efficient system in the transport of cartons of beer to the regions. Some of these benefits are:

(i) The optimal cost gives the transport manager an idea of the related cost associated with each warehouse where products are sent to

(ii) It aids in effective planning of the entire transportation within the company.

(iii) It equips the transport manager in budgeting for the transportation of products to the regions.

4.4 Modeling the data

Accra Breweries Limited (ABL) has two plants/sources at Accra and Kumasi respectively. It also has two major seasons of production being the Lean and Festive seasons. The festive season is normally during the Easter and Christmas seasons. During the festive season, there are a lot of activities and merry-making and as a result people tend to drink more.

Data was gathered for both seasons. Table 4.1 and 4.2 shows the supplies from the Accra and Kumasi sources, the monthly demands at all the ten regions of Ghana and the unit transportation cost in Ghana Pesewa from each source to each destination. Table 4.1 depicts the data for the lean season and Table 4.2 shows the data for the festive season.

According to the transport office of ABL at the Accra plant, the Accra plant serves the Greater Accra, Central, Western, Volta, Eastern, Brong-Ahafo and also Northern regions. The Kumasi plant also serves the Ashanti, Western, Eastern, Brong-Ahafo, Northern, Upper East and Upper West regions in Ghana.

Source 1- Kumasi Plant

Source 2- Accra Plant

Table 4.1 Lean Season Data for ABL

	CENTARL	ASHANTI	GREATER ACCRA	WESTERN	VOLTA	EASTERN	BRONG AHAFO	NORTHEN	UPPERR EAST	UPPER WEST	SUPPLY
SOURCE 1	10,000	2	10,000	18	10,000	35	15	45	75	80	176,849
SOURCE 2	15	10,000	2.2	15	25	25	50	70	10,000	10,000	240,273
DEMAND	26,695	39,314	117,741	19,584	21,965	10,104	15,861	47934	5,990	4,749	

Table 4.2 Festive Season Data for ABL

	CENTRAL	ASHANTI	GREATER ACCRA	WESTERN	VOLTA	EASTERN	BRONG AHAFO	NORTHERN	UPPER WEST	UPPER EAST	SUPPLY
SOURCE 1	10,000	2	10,000	18	10,000	35	15	45	75	80	216,849
SOURCE 2	15	10,000	22	15	25	25	50	70	10,000	10,000	285,273
DEMAND	43,245	64,173	175,941	35,767	30,875	22,573	19,165	59,934	18,403	15,180	

In modeling the transportation problem of ABL, values in tables 4.1 and 4.2 were used. Table 4.3 shows the optimal solution of the transportation problem of ABL per month to each destination during the seasons.

Table 4.3 shows the optimal cost solution for the lean season.

OPTIMAL COST= GH□50576.83	CENTRAL	ASHANTI	GREATER ACCRA	WESTERN	VOLTA	EASTERN	BRONG AHAFO	NORTHERN	UPPER EAST	UPPER WEST	DUMMY
SOURCE 1		39,314					15,861	47,934	5,990	4,749	63,001
SOURCE 2	26,695		117,741	19,584	21,965	10,104					44,184

4.5 Interpretation for optimal cost solution during the lean season.

The optimal solution results show that, the optimal transportation cost was GH¢50,576.83. The Kumasi plant with capacity 39,314 cartons per month during the lean season should supply only five (5) regions, namely Ashanti, Brong-Ahafo, Northern, Upper East and Upper West ware houses, with a capacity of 39,314, 15,861, 47,934, 5,990 and 4,749 respectively with a dummy of 63,001 cartons. The dummy of 63,001 for Kumasi indicates that the company could get the said amount for storage to meet future demand in the market.

Furthermore, the results indicate that the transportation of products from Kumasi to Western and Eastern regions must be cancelled during the lean season. Again, the transportation of products from the Accra plant to Brong- Ahafo and Northern regions should also cease during the lean season to help minimize the total transportation cost.

The Accra plant with capacity 117,741 cartons per month during the lean season should supply the Central, Accra, Western, Volta, and Eastern region warehouses with 26,695, 117,741, 19,584, 21,965, and 10,104 cartons respectively, with an excess of 44,184 cartons of beer stored in the company's warehouse in Accra for future use.

Table 4.4 presents the optimal solution for the lean season with their associated cost.

Table 4.4 Optimal Solution with Associated Cost for Lean Season

From	To	Shipment	Cost Per Unit	Shipment Cost
Source 1	Ashanti	39,314	2	78,625
Source 1	Brong-Ahafo	15,861	15	237,915
Source 1	Northern	47,934	45	2,157,030
Source 1	Upper East	5,990	75	449,250
Source 1	Upper West	4,749	80	379,920
Source 1	Dummy	63,001	0	0
Source 2	Central	26,695	15	400,425
Source 2	Greater Accra	117,741	2.2	259,030.2
Source 2	Western	19,584	15	293,760
Source 2	Volta	21,965	25	549,125
Source 2	Eastern	10,104	25	252,600
Source 2	Dummy	44,184	0	0

The optimal solution depicts that, a total of 39,314 cartons should be transported from the Kumasi plant to the indicated region at a cost of GH¢786.24, a total of 15,861 cartons should be shipped from the Kumasi plant to Brong-Ahafo region at a cost of GH¢2,379.15, also a total of 47,934 cartons per month is to be shipped to the Northern warehouse at a cost of GH¢21,570.30, at the Upper East and Upper West warehouses, a total of 5,990 and 4,749 cartons are to be shipped there at a cost of GH¢4,492.50 and GH¢3,799.20 respectively.

Finally to conclude the interpretation, the Kumasi plant is to leave 63,001 cartons of beer at the company's warehouse to help plan to meet future demands of the product.

From the Accra plant, it was seen that during the lean season, the company should transport the following cartons of beer with its associated cost to the various regions. A total of

26,695 to Central, at a cost of GH¢4,004.25, 117,741 cartons to Accra at a cost of GH¢2,590.302, 19,584 cartons to the Western region at a cost of GH¢2,937.60.

Furthermore, a total of 21,965 cartons are to be shipped to the Volta region at a cost of GH¢5,491.25 and lastly 10,104 cartons to the Eastern region at a cost of GH¢2,526.00 leaving a reserve of 44,184 at the Accra warehouse of the company to help meet supply in case there is shortage of the product on the market.

This result gives the optimal allocation of cartons of beer needed at each region to meet the demand and minimize the transportation cost of beer which also adds up to the production cost of ABL.

During the festive season such as Easter and Christmas, the production of beer by the company (ABL) increases due to merry -making during such seasons. Table 4.5 shows the optimal solution during the festive seasons.

TABLE 4.5 Optimal Cost Solutions for Festive Season

Optimal cost= GHc 86,853.10	Central	Ashanti	Greater Accra	Western	Volta	Eastern	Brong-Ahafo	Northern	Upper East	Upper West	Dummy
Source 1		64,173		23,128			19,165	59,934	18,403	15,180	
Source 2	43,245		175,941	12,639	30,875	22,573					

4.6 Interpretation for Optimal Cost Solution for Festive Season

The result for the optimal solution for the festive season shows that the total transportation cost was GH¢86,853.10 per month. The Kumasi plant should supply Ashanti region with 64,173 cartons every month, Western region with 23,128 cartons. Furthermore, the Kumasi

Plant should supply the Brong-Ahafo and Northern regions with 19,165 and 59,934 cartons of beer respectively during the festive season. Additionally, the Kumasi plant is again to supply the Upper East and Upper West regions with 18,403 and 15,180 cartons of beer and keep 16,866 cartons as dummy at the warehouse of the company in case there is shortage on the market during the season.

The Accra plant is to supply Central region with 43,245 cartons of beer during the festive season. It is also to supply Greater Accra region with 175,941 cartons of beer. Additionally, the Accra plant is to supply the Volta region with 30,875 cartons of beer and the Eastern region with 22,573 cartons during the season.

Interestingly, supply to the Eastern regions during the festive season is to be done by the Accra plant instead of both plants; additionally, supply to both the Brong Ahafo and Northern region from the Accra plant should also cease and be done by the Kumasi plant to help minimize the total transportation cost. The association cost of transporting cartons of beer to the various region during the festive season by the Accra plant are: central GH¢ 64,86,75, Greater Accra, GH¢ 3,870.702, Western, GH¢ 1,895.85, Volta, GH¢ 7718.75 and Eastern, GH¢ 5,643.25 as shown in Table 4.6

Table 4.6 Optimal Solution with Associated Cost for Festive Season

FROM	TO	SHIPMENT	COST PER UNIT	SHIPMENT COST IN GH PESEWAS
Source 1	Ashanti	64,173	2	128,346
" "	Western	23,128	18	416,304
" "	Brong - Ahafo	19,165	15	287,475
" "	Northern	59,934	45	2,697,030
" "	Upper East	18,403	75	1,380,225
" "	Upper West	15,180	80	1,214,400
" "	Dummy	16,866	0	0
Source 2	Central	43,245	15	648,675
" "	Gt. Accra	175,941	2.2	387,070.2
" "	Western	12,639	15	189,585
" "	Volta	30,875	25	771,875
" "	Eastern	22,573	25	564,325

4.7 Summary

In this chapter, we considered the data collected from ABL and analyzed it. The data was modeled as a transportation problem and Vogel's Approximation Method (VAM) was used to find an initial basic feasible solution after which the Modified Distribution Method (MODI) was used to improve the results to optimality using the Quantitative Manager for Windows (QMW) software.

The next chapter is reserved for conclusions and recommendations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter is devoted for the summary of the results, conclusions and recommendations of the study

5.1 Summary and Conclusions

This study was conducted in order to project the possibility of improving the transportation modeling methods into the existing transportation flow of Accra Brewery Limited (ABL). It further seeks to minimize the cost on transportation by finding an optimal solution for the routes from two production sources, that is, Accra and Kumasi to all the ten regions of Ghana (destination points).

Data was collected from ABL which showed the level of supply at each plant/ source, level of demand at each destination and the unit transportation cost from each source to each destination during the two seasons, namely the lean and festive seasons of ABL. This data gave the input to help minimize the total monthly cost of transporting beer from Accra and Kumasi to all the ten regions of Ghana.

The data was modeled using the transportation model. The Vogel's Approximation Method (VAM) was used to find the Initial Basic Feasible Solution (IBFS), after which the Modified Distribution Method (MODI) was used to improve the IBFS to optimality. The Quantitative Manager for Windows (QMW) software was then used to solve the modeled problem.

It was observed that during the lean season, the optimal monthly cost of transportation was GH¢ 50,576.86 and that of the festive season was GH¢ 86,853.10. The results show that there is much difference in the monthly transportation cost between the lean and festive season.

The author considered the study important, as the minimization costs and the transportation process may help improve ABL's position on the market and increase the profit margins of the company by reducing the expenses on transportation.

5.2 Recommendations

The physical distribution of goods to maximize profit and minimize transportation cost to satisfy the needs of arrival areas is one of the most important and successful applications of quantitative analysis. This is commonly referred to as the transportation problem. The purpose is to basically minimize the cost of transporting a single homogenous product from one or more sources to another to satisfy ones needs and also to make sure that every transporting location operates within its capacity.

For ABL to realize these objectives, the researcher recommends that the Accra and Kumasi plants should produce a little more than what it's currently producing during its festive season. The researcher further recommends that both the Accra and Kumasi plants should supply beer to the Eastern region during the festive season other than the Accra plant alone

Finally, the researcher recommends that ABL should adopt the proposed model in order to maximize profit by reducing transport costs.

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APPENDIX A

DATA FORMAT

PRODUCT: A

THE NUMBER OF CARTONS OF PRODUCT DISTRIBUTED OVER VARIOUS DEPOTS FROM JANUARY TO DECEMBER IN 2011

DEPOTS	MONTHS / CARTONS DISTRIBUTED											
	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC
ACCRA												
UMASI												
KOFORIDUA												
CAPE COAST												
TAKORADI												
SUNYANI												
HO												
TAMALE												
WA												
BOLGATANGA												

SHIPMENT DURING LEAN SEASON WITH ASSOCIATED COST

FROM	TO	SHIPMENT	COST PER UNIT	SHIPMENT COST IN GHANA CEDIS & PESEWAS
KUMASI/ASHANTI	ASHANTI			
KUMASI/ASHANTI	BRONG AHAFO			
KUMASI/ASHANTI	NORTHERN			
KUMASI/ASHANTI	UPPER EAST			
KUMASI/ASHANTI	UPPER WEST			
ACCRA/GT. ACCRA	GT. ACCRA			
ACCRA/GT. ACCRA	CENTRAL			
ACCRA/GT. ACCRA	WESTERN			
ACCRA/GT.	VOLTA			
ACCRA	EASTERN			

DATA FOR THE LEAN SEASON TRANSPORTATION FOR ACCRA BREWERY LIMITED

SOURCE/DESTINATION	CENTRAL	ASHANTI	GREATER ACCRA	WESTERN	VOLTA	EASTERN	BRONG AHAFO	NORTHEN	UPPER EAST	UPPER WEST	SUPPLY
KUMASI/ASHANTI											
ACCRA/GREATER ACCRA											
DEMAND											

DATA FOR THE FESTIVE SEASON TRANSPORTATION FOR ACCRA BREWERY LIMITED

SOURCE/DESTINATION	CENTRAL	ASHANTI	GREATER ACCRA	WESTERN	VOLTA	EASTERN	BRONG AHAFO	NORTHEN	UPPER EAST	UPPER WEST	SUPPLY
KUMASI/ASHANTI											
ACCRA/GREATER ACCRA											
DEMAND											

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

INSTITUTE OF DISTANCE LEARNING

TOPIC: THE TRANSPORTATION PROBLEM OF ACCRA BREWERY LIMITED

INTERVIEW GUIDE

The purpose of this interview guide is to find out the transportation problem of Accra Brewery Limited.

Your response would help the researcher to give more insight academia and also to offer some optimal solution to the transportation problem of ABL. It would be very much appreciated you could make a little time off to provide frank responses to the questions provided.

You are assured that, all the information you provide will be treated very confidential.

Thank you in advance for your co-operation.

1. How many Plants/Supply points have ABL?

   ……

2. Where can the plant(s) be located? ……………………………………………………………………………………….

   ……

3. How many warehouses/destinations have ABL across the country? …………………...

   ………………………………………………………………………………………………

4. Would you say you have lean season? …………………………………………………....

   ………………………………………………………………………………………………

5. During which time of the year can you say it is lean? …………………………………

   ………………………………………………………………………………………………

6. On the average, what is the capacity of each plant per month during the lean season?

………………………………………………………………………………………………

7. During which time in the year is the festive? …………………………………………

………………………………………………………………………………………………

8. What is the average capacity of each plant per month during festive season? ………...

………………………………………………………………………………………………

9. Averagely, what is the demand of beer (cartons) demanded from each ware house per month during the lean season? …………………………………………………………

………………………………………………………………………………………………

10. What is the average demand of beer (cartons) demanded from each ware house per month during the festive season? …………………………………………………

…………………………………………………………………………………………….

11. What is the unit transportation cost from each source to each major warehouse? ……..

………………………………………………………………………………………………

❖ Which destinations does the Accra plant reach? …………………………………..

……………………………………………………………………………………………..

❖ Which destinations does the Kumasi plant go? ……………………………………

……………………………………………………………………………………………..

❖ What determines the transportation cost of ABL? ………………………………

………………………………………………………………………………………..