KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

INSTITUTE OF DISTANCE LEARNING

OPTIMAL PRODUCTION SCHEDULING, CASE STUDY:

GUINESS GHANA BREWERY LIMITED, KUMASI

BY

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DECLARATION

I hereby declare that this project work was fully undertaken by me under supervision and has not in part or whole been presented for another project.

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ABSTRACT

As Production systems expand, there is a tendency for the scheduling activities to become complex, or at least more demanding with respect to the time required for their performance Previous production scheduling involves complicated iterative procedures. A new approach brings out the basic principle involved and leads to a simple solution.

Production of a given commodity is to be scheduled for a regular and capacity to meet known future requirements while minimizing total production and inventory costs.

For the objective function, I intend to find the optimum production schedule by minimizing the total production and inventory cost calculated through the production schedules of orders. The Northwest Corner Rule, the Least Cost Method, and the Vogel's Approximation Method (VAM) were used to obtain an initial basic feasible solution (bfs). Improving solution to optimality was carried out using The Modified Distribution Method (MODI).

The production was modelled as a balanced transportation problem and solved using an excel solver to obtain the optimal production schedule and the results reported. Results from the analysis indicated that the company need not carry out overtime production throughout the year but should apply scheduling to their production activities to ensure cost reduction, optimum utilization of capacity, proper inventory control management, overall quality output and above all optimality.

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DEDICATION

I dedicate this project to my late father, Mr. Emmanuel Kwame Asamoah whose motivation, love and support at different times in my life over many years has made the production of this project possible and all the help I needed when he was alive.

To Miss Mary Konadu, my dear mother for her joy that reminds me to have a smile on my face.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The performance of any company depends both on its technological expertise and its managerial and organizational effectiveness. Production management is an important part of the process for manufacturing firms. The organization of production relies in general on the implementation of a certain number of basic functions, among which the scheduling function plays an essential role.

Production scheduling is a unifying problem closely related to other areas within an organization such as sales, cost control, purchasing, capital budgeting and inventory management (Pounds, 1961). Magee (1956), emphasized the interrelationships between these two important production management activities. Irrespective of organizational status, it is generally recognized that production scheduling and inventory management, or control, are closely interrelated. In theory, problems are frequently classified according to type of problems, example distribution, queuing or sequencing. However, real industrial problems often do not fit into rigid categories (Ackoff, 1956).

Scheduling is the establishment of starting and finishing dates for productive activities (Rago, 1963). Under certain conditions, scheduling may also determine the sequence of operations and/ or the assigned workload on certain equipment. For example, as the size of the scheduling matrix increases, (i.e., more orders to be assigned to a larger array of machines) the number of possible combinations of routings increases exponentially (Giffer, |Thompson and Vanness, 1963).

However, the accomplishment of the scheduling function should not generally imply that rank orders have been set or specific machine loads determined. The term scheduling is often used to describe the sequencing situation. Scheduling should be reserved for procedures which give the time of arrivals units requiring service (Sission, 1991). Sequencing is defined as determining the order in which items are processed. The scheduling of complex activities, particularly when job-process times are short, does not explicitly determine the order of work for manufactured items. Scheduling –sequencing problems are, therefore, concerned with determining both the time that the order processing is completed and the rank order, that is , the sequence of order processing.

Scheduling concerns the allocation of limited resources to tasks over time. Bitran (1983) explained " Production scheduling is concerned with the allocation of resources and the sequencing of tasks to produce goods and services. Although allocation and sequencing decisions are closely related, it is very difficult to model mathematically the interaction between them. However, by using a hierarchical approach, the allocation and the sequencing problems can be solved separately. The allocation problem is solved first and its results are applied as inputs to the sequencing problem. The resource allocation problem can sometimes be solved using aggregate production planning techniques. To specify completely the input to the sequencing problem, the resulting detailed or item plan (also referred as the master schedule) has to be disaggregated. A breakdown by component parts can be obtained in a straightforward way by using Material Requirements Planning (MRP) systems. Although MRP continues to be popular in practice, many issues still need to be resolved to make it an effective production planning tool".

Production scheduling has three goals or objectives. The first involves due dates and avoiding late completion of jobs. The second goal involves throughput times; the firm wants to minimize the time a job spends in the system, from the opening of a shop order until it is closed or completed. The third goal concerns the utilization of work centers. Firms usually want to fully utilize costly equipment and personnel. Often, there is conflict among the three objectives. Excess capacity makes for better due –date performance and reduces throughput time but wreaks havoc on utilization. Releasing extra jobs to the shop can increase the utilization rate and perhaps improve due-date performance but tends to increase throughput time.

Vollman et al., (2005) noted that the production schedule is derived from the production plan; it is a plan that authorized the operations function to produce a certain quantity of an item within a specified time frame. In a large firm, the production schedule is drawn in the production planning department, whereas, within a small firm, a production schedule could originate with a lone production scheduler or even a line supervisor.

There are fundamental differences in production planning and production scheduling. Planning models often utilize aggregate data, cover multiple stages in a medium –range time frame, in an effort to minimize total costs. Scheduling models use detailed information, usually for a single stage or facility over a short term horizon, in an effort to complete jobs in a timely manner. Despite these differences, planning and scheduling often have to be incorporated into a single framework, share information, and interact extensively with one another. They may also interact with other models such as forecasting models or facility location models.

Bartak (1999) stated that " the main difference is in the resolution of the resulting plan or schedule. While the industrial planning deals with the task of finding " rough" plans for longer period of time where activities are assigned to departments etc., the industrial scheduling deals with the task of finding detail schedules for individual machine for shorter period of time. From this point of view, scheduling can be seen as a high- resolution short –term planning".

A production schedule can determine whether delivery promises can be met and identify time periods available for preventive maintenance. Production schedule gives shop floor personnel an explicit statement of what should be done so that supervisors and managers can measure their performance.

- Minimize average flow time through the system.
- Maximize machine and /or worker utilization.
- Minimize setup times.

A production schedule can identify resource conflicts, control the release of jobs to the shop, and ensure that required raw materials are ordered in time.

Better coordination to increase productivity and minimizing operating costs. It should be noted that a major shift in direction has occurred in recent research on scheduling methods. Much of what was discussed was developed for job shops. As a result of innovations such as Computer Integrated Manufacturing (CIM) and Just-In-Time (JIT), new processes being established in today's firms are designed to capture the benefits of repetitive manufacturing and continuous flow manufacturing. Therefore, much of the new scheduling research concerns new concepts and techniques for repetitive manufacturing-type operations. In addition, many of today's firms cannot plan and schedule only within the walls of their own factory as most are an entity with an overall supply chain. Supply chain management requires the coordination and integration of operations in all stages of the chain. If successive stages in a supply belong to the same firm, then these successive stages can be incorporated into a single planning and scheduling model. If not, constant interaction and information sharing are required to optimize the overall supply chain.

A Production schedule can identify resource conflicts, control the release of jobs to the shop, ensure that required raw materials are ordered in time, determined whether delivery promises can be met, and identified time periods available for preventive maintenance (Fordyce, 2005).

Production scheduling and Control entails the acquisition and allocation of limited resources to production activities so as satisfy customer demands over a specified time frame. As such, planning and control problems are inherently optimization problems, where the objective is to develop a schedule or plan that meets demand at minimum cost or that fills the demand that maximizes profit subject to constraints.

Production scheduling and planning may be defined as the technique of foreseeing every step in a long series of separate operations; each step to be taken at the right time and in the right place and each operation is to be performed in maximum efficiency. It helps entrepreneur to work out the quantity of material manpower, machine and money required for pre-determined level of output in a given period of time.

With the current global markets and global competition, pressures are placed on manufacturing organizations to compress order fulfilment times, meet delivery commitments consistently and also maintain efficiency in operations to address cost issues (McCarthy, 2006). It is in respect of this that many manufacturing facilities find it expedient to generate and update production schedules, which are plans that state when certain controllable activities (example, processing jobs by resources) should take place. In manufacturing systems with a wide variety of products, processes and production levels, production schedules can enable better coordination to increase productivity and minimize operating costs. A production schedule can identify resource conflicts, control the release of jobs to the shop, and ensure that required raw materials are ordered in time. A production schedule can determine whether delivery promises can be met and identify time periods available for preventive maintenance. A production schedule gives shop floor personnel an explicit statement of what should be done so that supervisors and managers can measure their performance (Herrmann, 2006).

In practice, production scheduling has become part of the complex flow of information and decision-making that forms the manufacturing planning and control system. This decision-making systems enhances production scheduling (Herrmann, 2006). Planned production is an important feature of both small and large industries.

Wight (1984) identified “priorities” and “capacity” as the two key problems in production scheduling. In other words, “What should be done first?” and “Who should do it?”. He defined scheduling as “establishing the timing for performing a task” and observes that in manufacturing firms, there are multiple types of scheduling, including the detailed scheduling of a shop order that shows when each operation must start and complete. (Cox et al., 1992) defined detailed scheduling as “the actual assignment of starting and / or completion dates to operations or groups of operations to show when these must be done if the manufacturing order is to be completed on time”. They note that this is also known as operation scheduling, order scheduling and shop scheduling.

Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility what ton to make, when, with which staff, and on which equipment. Thus, the production scheduling aims to maximize the efficiency of the operation and reduce costs.

Production scheduling tools greatly outperform older manual scheduling methods. These provide the production scheduler with powerful graphical interfaces which can be used to visually optimize real-time work loads in various stages of production and pattern recognition allows the software to automatically create scheduling opportunities which might not be apparent without this view into the data. For example, an airtime might wish to minimize the number of airport gates required for its aircraft, in order to reduce costs, and scheduling software can allow the planners to see how this can be done, by analyzing time tables, aircraft usage, or the flow of passengers.

Companies use both backward and forward scheduling to allocate plant and machinery resources, plan human resources, plan production processes and to purchase materials. Forward scheduling is planning the tasks from the date resources become available in order to determine the shipping date or the due date. Backward scheduling entails planning the tasks from the due date or required-by date to determine the start date and /or any changes in capacity required.

Production schedule is prepared on the basis of type of production process involved. It is very useful where single or few products are manufactured repeatedly at regular intervals. Thus, it would show the required quality of each product and the sequence of operation. Modern production techniques and organization can create many production abilities by which different production systems (with the quality of goods and production schedule) and different production costs are formulated. It is reasonable to develop a production system or schedule that can ensure production quality and schedule at minimum cost.

Production scheduling can be difficult and time-consuming. In a dynamic and stochastic manufacturing environment, managers, production planners and supervisors must not only generate high-quality schedules but also react quickly to unexpected events and revise schedules in a cost-effective manner. These events, generally difficult to take into consideration while generating a schedule, disturb the system, generating considerable differences between the predetermined schedule and its actual realization on the shop floor. Rescheduling is then practically mandatory in order to minimize the effect of such disturbances in the performance of the system.

There are certain firms or organizations, which have to produce commodities or items at certain intervals over a given period to ensure that together with what is held in inventory (storage), there is enough to meet all demands. Since storage space for inventoried items is limited, there is a limit to how much commodity that can be put in inventory. After production has taken place to meet demand for the current quarter or season, there is always a production cost incurred, together with a carrying, holding, set up inventory or storage cost.

Because production scheduling activities are common but complex, there exist many different views and perspectives of production scheduling. Three important perspectives have been identified and these are the problem-solving perspective, the decision making perspective, and the organizational perspective. Each perspective has a particular scope and its own set of assumptions. Different perspectives lead naturally to different approaches to improving production scheduling.

The problem-solving perspective holds the view that scheduling is an optimization problem that must be solved by moving tasks around a Gantt chart, searching for the optimal solution. A great deal of research effort has been spent developing methods to generate optimal production schedules. Typically, such papers formulated scheduling as a combinatorial optimization problem isolated from the manufacturing planning and control system in place. More generally, the ability to formulate the problem rigorously and to analyze it to find properties of optimal solutions has attracted a great deal of research effort.

In addition to exact techniques, Brucker (2004) used a variety of heuristics and search algorithms to find near-optimal solutions to these problems. Although there exist significant gap between scheduling theory and practice, some researchers have improved real-world production scheduling through better problem-solving (Dwaine et al. , (2004). Gantt (1973), reacting to situations that he has observed ninety years ago, warned that the most elegant schedules created by planning offices becomes useless if they are ignored.

The second is the decision-making perspective, where the production scheduling objective is "to see to it that future troubles are discounted (Coburn, 1981). There are many types of disturbances that can upset a production schedule, including machine failures, processing time delays, rush orders, quality problems, and unavailable materials. Problems can be caused by sources outside the shop floor, including labour agreements and the weather. It is unlikely that such a wide variety of possible problems can ever be considered automatically, implying that computers will never completely replace human schedulers. Moreover, improving production scheduling requires that the schedulers manage bottle neck themselves), and take steps to handle future uncertainty (McKay and Wiers, 2004).

Scheduling decision support systems can be useful as well. As suggested by McKay and Wiers (2006) and Wiers (1997), the design of a scheduling decision support tool should be guided by the following concepts:

(a) The ability of the scheduler to directly control the schedule (called "transparency),
(b) The amount of uncertainty in the manufacturing system
(c) The complexity of the scheduling decision and
(d) How well-defined the scheduling decision is characterized by incompleteness, ambiguity, errors, inaccuracy, and possibly missing information.

The organizational perspective considers scheduling as part of the complex flow of information and decision-making that forms the manufacturing planning and control system (Herrmann, 2004; McKay et al., 1995). Such systems are typically divided into modules that perform different functions such as aggregate planning and material requirements planning (Hopp and Spearman, 1996). The organizational perspective, which is the most complete, views production scheduling as a system of decision-makers that transforms information about the manufacturing system into a production schedule (Herrmann, 2004).

In a manufacturing facility, the production scheduling system is a dynamic network of persons who share information about the manufacturing facility and collaborate to make decisions which jobs should be done and when. The information shared includes the status of jobs (also known as work orders), manufacturing resources (people, equipment and production lines), inventory (raw materials and work-in-process) tooling, and many other concerns. The persons in the production scheduling system may be managers, production planners, supervisors, operators, engineers, and sales personnel. They will use a variety of forms, reports databases and software to gather and distribute information, and they will use tacit or implicit knowledge that is stored in their memory.

Based on the above decision, it is clear that these three perspectives forms a hierarchy, with the problem-solving perspective at the lowest level, the decision-making perspective in the middle and the organizational perspective at the highest level.

Within the manufacturing set up, the challenge exist where production managers are unable to meet customers' orders or demand on time. Unfortunately, many manufacturers have ineffective production scheduling systems. They produce goods and ship them to their customers, but they use a broken collection of independent plans that are frequently ignored, periodic meetings where unreliable information is shared, expediters who run from one crisis to another, and ad-hoc decisions made by persons who cannot see the entire system. Production scheduling systems rely on human decision makers, and many of them need help dealing with the swampy complexities of real-world scheduling (McKay and Wiers, 2004).

The main tool used to control product availability is the application of a production schedule. By using the beginning inventory and the sales forecast for a particular end item, a planner or manager can calculate the amount of products or goods needed per period to meet anticipated customer demands. The production problem for such organization or firm is the setting up a production and inventory schedule that minimizes the total production and storage costs while meeting all demands for the given period.

1.2 A BRIEF HISTORY OF KUMASI BREWERY LIMITED.(K B L)

Guinness Ghana has three sites, namely Achimota, in Accra, Ahensan in Kumasi and Kaase also in Kumasi. Guinness Ghana Breweries Limited (GGBL) emerged out of a merger of Guinness Ghana Limited (GGL) and Ghana Breweries Limited (GBL). To understand the history of GGBL therefore it is necessary to provide separate information on GGBL and GBL prior to 2004, the year in which the merger process commenced.

1.2.1 Guinness Ghana Brewery Limited (GGBL)

Guinness Ghana Limited was incorporated as a private company in 1960 and was listed on the Ghana Stock Exchange in 1990. When it was incorporated, Guinness Ghana Limited was to manage the importation and marketing of Guinness Foreign Extra Stout in Ghana. The shareholders were Guinness Overseas Limited (67.5%) and Atalantaf, a Bermudan Company (32.5%). In 1971, a brewery was designed and constructed in Kaasi, Kumasi. Production commenced a year later on 11 November 1971 with an installed capacity of 100,000 hectolitres. By 1977, the brewery was producing at maximum capacity. In 1976 Government of Ghana by an Investment Policy Decree acquired 40% of the shareholding in the Company. Other shareholders were Guinness Overseas Limited (28.68%), Atalantaf Limited (16.32%), Individuals (12.72%), Institutions (1.18%) and Employees (1.10%). The shareholding structure changed again when Government of Ghana divested its holding in the 1990s.

In May 1995, Guinness Ghana invested 18 billion cedis to expand its packaging capacity and commissioned in July 1999 a 40 billion cedis fully automated brew house facility using state of the art brewing and process control technology. This process allows product testing at every stage of the brewing process, thus delivering world-class purity and excellence throughout. In November 2003, Guinness Ghana commissioned a second state of the art packaging line at a cost of 165 billion cedis.

Guinness Ghana initially produced Foreign Extra Stout only. In 1989 it introduced Malta Guinness, a non-alcoholic beverage that was later produced in other markets in Africa. By the close of 2003 the Company had a range of products covering stout beer, malt drinks and "ready-to-drink" market. In 2003 financial year Guinness Ghana produced 576,000 hectoliters of its products As at 31 December 2003, the Company had a volume share of 31.3% of the combined beer and "ready-to-drink" market and 72.7% of the malt drinks market (as per AC Nielson d

As at 30th October 2009, the range of Guinness Ghana Brand products covering: Mini Star (24x1), Gordon Spark (24x1), Star Large (12x1), Malta Guinness Quench (24x1), Amstel Malta (24x1), Malta Guinness can (24x1), Malta Guinness (24x1), Malta Guinness Quench can (24x1,Gulder Large (12x1), Heineken can/bottle (24x1), Guinness FES (24X1), Star Draft 30L Keg, Smirnoff Ice (24x1), Guinness FES can (24x1), Alvaro (24x1), Smirnoff /J& B /Gordon's ata). Guinness Ghana Breweries Limited becoming a total beverage business by bringing the Diageo Spirit Brands into the GGBL portfolio. These branded products that is being imported and sold on behalf of other companies are Johnny Walker (Red or Black), Baileys/J&B.

1.2.2 GHANA BREWERIES LIMITED (GBL)

Ghana Breweries Limited was incorporated on 30th April, 1992 under its previous name, 'ABC Brewery Limited. On 26th October 1994, it acquired the assets of Achimota Brewery Company Limited, a state-owned enterprise operating at Achimota, Accra. In October 1997, Heineken International acquired 90% of the outstanding ordinary shares of ABC Brewery Limited and subsequently renamed the company Ghana Breweries Limited. Ghana Breweries than merged with Kumasi Brewery Limited, a brewing company established in May 1959, with effect from

1st January 1998. Before this merger, Heineken and its wholly owned subsidiary, Limba Ghana Limited, held 50.26% of the issued shares of Kumasi Brewery Limited.

In June 2003, Ghana Breweries underwent a capital restructuring exercise. Consequently the stated capital of the Company increased from Cedi 74.4 billion to cedi 144 billion. Heineken Ghanaian Holdings held 75.59% while institutional and individual investors held 24.41% of the Company's shares.

Ghana Breweries' range of product covered beer (lager), malt drinks and soft drinks. As at 31st December 2003, had a volume share of 39.5% of the combined beer and "ready -to-drink-" market and 23.3% of malt drinks marker (according to AC Nielson data).

1.2.3. MERGER

In 2004 Guinness Ghana Limited and Ghana Breweries Limited began a merger process. Up to 2007 the two Companies transacted business together as two separate legal entities under the new name "Guinness Ghana Breweries Limited". The merger process ended when Guinness Ghana Breweries Limited acquired all the assets of Ghana Breweries Limited in 2008.

1.2.4 SUPPLIERS

GGBL has System SAP that registered all its suppliers of goods and services. Its registered vendors and suppliers strictly to provide goods and services. Goods are ordered from the registered suppliers. Suppliers are typically selected based on the supplier's ability to meet quality, quantity, delivery, and right source of product, price and services. Where there existing more than two suppliers; each supplier will have to sent his or her quotation for particular order where upon consideration and deliberation by the procurement board the order is assigned to one

with minimum quotation and with quality goods and services, product standard. For one to become GGBL supplier he or she must meet the following conditions:
Good Ethics and Human Right Management Records.

These includes, safe working environment, pay and working hours, Anti-corruption and bribery, Tax Royalty, Valid Vendors Registration certificate, Supplier financial standings, Verification indicating reliable source and reliable of goods and more.

1.2.5 MANUFACTURING:

The Kaase site operates at an installed and target capacity of eleven million hectoliters per annum. The site operates an ultra modern brewing department, a modern and highly automated Packaging unit and distribution operations.

In order to be able to beat the competition and gain market share, Guinness Ghana Breweries injected capital into its operations by investing modern equipment. These include tanks, Gas processing plant, refrigeration plant, a new brew house and an ultra modern Packaging Plant. The Packaging plant is highly automated. This investment is in line with the company's objective of achieving One million, one hundred thousand hectoliters of beer per annum. The packaging plant is well supported with back up spares and world-class maintenance practices.

The GGL uses modern Brewery automated system to brewery and bottled its beverages. The manufacturing material inventory includes the ingredients, empty bottles, lids, crown corks and label. Drinks are brew and package at the packaging Hall. The finish products are then arranged in pallet and moved to the warehouse prior to be distributed to the Distributors.

1.2.6 MALTA GUINNESS (SOFT DRINK)

Malta, young beer or wheat soda is a type of soft drink. It is carbonated malt beverage, meaning it is brewed from barley, hops and water much like beer; corn and caramel colour may also be added. However, Malta is non-alcoholic and is consumed in the way as soda or cola in its original carbonated form, and to some extent, iced tea in non-carbonated form. In other words, Malta is actually a beer that has not been fermented. Most scholars and Historians believe that Malta is the direct ancestor of all soft drinks. It is similar in colour to stout (dark brown) but is very sweet, generally described as tasting like molasses. Unlike beer, ice is often added to Malta when consumed. A popular way Latin Americans sometimes drink Malta is by mixing it with condensed or evaporated milk.

Nowadays, most Malta is brewed in the in the Caribbean and can be purchased in areas with substantial Caribbean populations. Aside from the islands of the Caribbean, Malta is also popular in Caribbean costal areas such as Panama, Colombia, and Venezuela and countries that share a Caribbean coast. Malta is brewed worldwide, and is popular in many parts of Africa like Nigeria, Chad, Ghana, and Cameroun and in the Indian Ocean. This beverage is also popular in several parts of Europe, especially Germany.   Malta Guinness is brewed under license internationally.

Malta originated in Germany, as Malzbier ("malt beer"), a Malty dark beer whose fermentation was interrupted at approximately 2%, leaving quite a lot of residual sugars in the finished beer. Up to the 1950s, Malzbier was considered a fortifying food for nursing mothers, recovering patients, the elderly etc.

Malzbier in its native form was finally superseded during the 1960s by its modern form, formulated from water, glucose syrup, malt extracted and hops extract, which had been on the market since the latter half of the 19^{th} century, notably in Denmark. Such formulated drinks are to be called Malztrunk ("malt beverage") according to German law, since they are not fermented. In colloquial use, Malzbier has nevertheless remained, along with other nicknames such as Kinderbier ("children's beer"). Some native Malzbiere can still be enjoyed in German, notably in Cologne, where the taps of breweries Malzmuhle and Sion sell it alongside their traditional Kolsch. Many German breweries have a Malta in their range, sometimes produced under license (for example Vitamalz).

Malta is also occasionally called " champagne cola" by some brands. However, there is a separate type of drink with this name, having a flavour and consistency more akin to cream soda. Despite this appellation, neither drink is champagne or a cola. Due to its distinctive colour, Malta is sometimes known as black brewed beer. Malta is high in vitamins B. Some breweries, like Albani Brewery of Denmark, fortify their non alcoholic Malta beverages with Vitamin B complex. Albani Brewery claims on their website to have been the first brewery to create non-alcoholic malt beverage in 1859

1.2.7 WAREHOUSE

Raw materials, semi-finished goods and finished are kept at the warehouse at Ahensan and Kaase store House.

Some of the transporters like Maesk have their own warehouse where they kept raw materials on behalf of GGBL .The goods are held in Maesk warehouse till request from GBBL to deliver goods for production.

1.2.8 TRANSPORTATION

The distribution of raw materials, semi-finish and the finish product is outsourced to third party contractors. Thus GGBL operate in 3 party logistics, which ensures materials, and finished goods are delivered at the right time to the right place in accordance with the planning schedule and at a minimum cost. There few registered transporters that are responsible for loading, packing, off loading and movement of raw material from port to warehouse, movement of finished products from Production warehouse to distributors. The main transporters are JoonMore, Maesk, DHL and Adom. The Maesk is the main distributor that clears Guinness goods from the Port and held it in their warehouse till Guinness Ghana Breweries make a request for goods to be used for production. The Logistics managers of Maesk send daily report to GGBL detailing the available stock in the inventory and goods used up. Based on the report that GGBL will determine to make re-order or replenish stock. To be become a GGBL distributor one has to tender and if meet the GGBL requirement you then be accepted as a registered transporters. The criteria for transporters selection are:

Goods in transit policy. The transporters must have good insurance package for all its fleet and truckload damage recover policy.

Maintenance planning schedule. Every transporter must have two weeks maintenance schedule

Driver. Transporters must have qualified and competent drivers who must be able to read and write.

Number of Fleet. At least every transporter must have 10 fleets including folk lifts.

1.2.9 DISTRIBUTION:

Finished products are sold directly to registered distributors. The distributors are the main agent who sells to retailers. The practice of exclusive distribution where only specially registered or authorized distributors (typically at least 5 distributors per a region) is the order of the day. These distributors act as wholesalers that sell directory to the publics and so called "Beer Bars". The GGL has their set rules and regulation governing registration and selection of a Key Distributors. There are 5 key factors required for someone to become a GGBL Key Distributor. They are listed below:

Financial standing: The Company must be able to have both physical assets to proof as collaterals as well as cash of not less than 25 thousand Ghana cedis, must also have large warehouse and parking space, must have staffs for administration task, packaging and drivers, must also have a fleet of cars for his transportation needs.

Tax royalty

Risk free and easy accessibility to parking space to enable discharging, loading and packing of bottles.

The names of registered Distributors in Ashanti Region are Ricky, Blue Banana, Afuakwa, Kayad, Askus.

1.3 STATEMENT OF THE PROBLEM.

1. To plan the work schedules of GGBL to make their production cost effective.
2. To regulate the overlap work done by regular and overtime staffs of GGBL to achieve maximum production and reduce cost.

1.4 OBJECTIVES OF THE STUDY

1. To model workers schedule as transportation problem
2. To find optimal solution to the transportation problem
3. To minimize production cost.

1.5 METHODOLOGY

The problem of workers schedule at Guinness Ghana Brewery Limited (GGBL) will be modeled as a transportation problem which can easily be solved using a simplex pivot method.
Simplex Pivots for these problems do not involve multiplication but are reduced to additions and subtractions. For this reason, it is desirable to formulate a production problem as balanced transportation problem using transportation algorithm to solve.
An excel solver will be used in solving and analysising the data to obtain the optimal solution.
The data will be collected at GGBL for the analysis. The overtime production and regular production schedules for one year period will be considered, thus from the period of July 2008 to June 2009.
The information required for this project will be gathered from the internet, the libraries, and Journals.

1.6 JUSTIFICATION OF THE STUDY

A number of studies on production scheduling problems have been carried out during the past years. This context will emphasize on production scheduling, machine capacity problem and freight scheduling problem.

The scheduling is applied in procurement and production, in transportation and distribution and in information processing communication.

In manufacturing, the scheduling function coordinates the flow of parts and products through the system and balances the workload on machines and personnel, departments and the entire plant.

Again a production scheduling can identify resource conflicts, control the release of jobs to the shop, and ensure that required raw materials are ordered in time.
Moreover, scheduling reduce the workload of workers there by improving quality health of workers.
Lastly, schedulers become well vest in production problems there by researching into it to improve good production schedules.

1.7 ORGANIZATION OF THE STUDY

This thesis consists of five chapters. The first chapter covers the introduction of the study and a brief history of Kumasi Brewery Limited, Kaase, Kumasi (KBL) In the second chapter, the literature review relevant to this research is considered. Chapter three discusses the methodology, appropriate model to be used and data collection. The fourth chapter deals with the computations procedure, data analysis and result. Chapter five which is the last chapter, deals with the summary, conclusion and recommendation.

1.8 SUMMARY

In this chapter considered the background of the study, statement of the problem, outlined the objectives of the study, justified the study, discussed briefly the method to be used and discussed how the study would be organized. A brief history of Guinness Ghana Brewery and Ghana Breweries Limited were put forward. In the next chapter, I shall put forward the pertinent literature review in production problem.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter will focus on studies carried out by researchers on production scheduling in the construction, manufacturing, mining, food and beverage industries, among others.

2.1 LITERATURE REVIEW

Several researchers proposed solutions to the production scheduling problem. For a single product environment under condition of demand uncertainty in a master of production schedule, Sridharan and Berry (1990) showed that increasing the length of the frozen interval improves schedule stability but that also increases cost.

Chung and Krajewski (1986) demonstrated that in a hierarchical production planning framework for a rolling horizon Master Production Schedule (MPS), the product cost structure influences the optimal choice of frozen interval lengths. In a comparative study, Sridharan and LaForge (1989) found that freezing a portion of the Master Production Schedule produces lower lot-sizes cost and more stable schedule than using safety stock at the MPS level.

Cambell (1992), using three different method for determining safety stock requirement, concludes that as the length of frozen interval increases there could be a greater need for safety stock.

Lin and Krajewski (1992) identified three MPS factors, namely, the length of the frozen interval, the re-planning interval, and the forecast window that could have a significant impact on the total system costs.

Zhao and Lee (1993) used a simulation model that showed that longer frozen intervals could lead to greater scheduling stability but at the expense of lower customer service level and higher total cost. In contrast, Sridharan and LaForge (1994), assumed a single product environment, stated that increasing the freezing interval does not result in a major loss in a customer service (as measure by product availability), but increased freezing does lead to higher end-item inventory. Although these authors have addressed some issues of MPS stability and its impact on product availability, they often assume a single item production environment with no capacity constraints.

Venkataraman (1996) conducted a research that dealt with real world conditions involving a case study of MPS stability for paint manufacturing. He found that under conditions of minimum batch-sizes and demand certainty, freezing the MPS leads to considerably high levels inventory and high cost during peak periods of demands. In addition, Zhao, Xie and Jiang (2001) provided a comprehensive analysis of lot-sizing choice and freezing of the MPS as related to stability. Both of these studies analysis MPS stability under conditions of finite capacity (FC), an important consideration in the real world of manufacturing. As noted, several previous studies of MPS stability under conditions of infinite capacity exist, however, Zhao, Xie and Jiang (2001) comment, “it is uncertain whether the result found under incapacitated systems can be applied to capacitated systems.

According to Vieira (2006), although Master Production Scheduling (MPS) has been studied and used by both academia and industries for quiet a long time, the real complexity involved in making a master plan when capacity is limited, when products have the flexibility of been made at different productions lines, and when performance goals are tight and conflicting has not yet been presented in a simple and practical way. He considered how to attain a given performance by balancing different objectives, such as maximizing service level, and minimizing inventory levels, risk of stock- outs, over time, and set up time.

According to Choo (1998), many decisions need to be made during the development of an MPS, such as; which product should be scheduled, in what quantity, and to which resources? Is over time needed? Should inventory be built for future periods? Should backlogging be considered? Clearly an MPS process depends on the combination of many different parameters. For this type of problem, it is extremely difficult to find a solution that satisfied all objectives involved simultaneously, mainly because of the great number of variables involved. It is known that finding an optimal MPS solution for industrial scheduling scenarios is time consuming despite nowadays computers being extremely fast. It is common, therefore, to use heuristics (metal-heuristics) to find good plans in reasonable computer time.

Floudas (1995) said, most construction managers are continually facing a situation in which they must take a decision whether to complete the project sooner than originally specified in the contract because of the clients request and/ or to optimize the cost of expediting. The plan duration is decreased by crashing all critical activities either by authorizing over time work or applying additional resources.

Senouci and Eldin, (1996) used methods such as Critical Path Method (CPM) and Programme Evaluation and Reviewed Techniques (PERT) to established a feasible and desirable relationship between the time and cost of project by reducing the target time and taken into account the cost of expediting. A number of graphical scheduling methods were developed for planning and scheduling of construction projects and these were the line of balance and vertical production methods. These techniques were neither suitable for the scheduling of linear projects or adequate for addressing typical challenge related to time-cost, trade-off.

Birrel, (1980) said, failure of many contractors to fully use CPM or PERT exposes fundamental failures in these models. Field and academia research have failed to question the feasibility of the network technique for construction. It is suggested that these methods are neither a true models nor best approximate model of the construction process because; control of construction resources is more desirable than minimum calendar duration of the whole project. Therefore, minimizing cost is an objective to be considered as much as minimizing the over all duration.

Ackoff (1963) said optimal schedule cost can be determined by try and error for small project, but realistic project consisting of many activities, such trial-and error becomes extremely tedious and impossible. A very limited number of computer programmes are available but far from perfect. Such programmes have a limited capacity to accept time-cost data and at a very high price. Other limitations of these programmes are that, the only data the computer can handle is the time-cost slope for individual activities.

Applequist G (1997) proposed that, another serious shortcoming has been the computational time when changes of network logic are involved. Finally, the excessive or inappropriate use of computers especially in a moderately sized network is another major factor of such failures. Because of these major failings, such programs have led to dissatisfaction and found little acceptance in the construction industry.

Barany et.al,(1984) Increased sophistication in optimization techniques have led to examine the possibility of incorporating a time-cost trade –off within an optimization framework.

Cattrysse and Maes (1990) When changes in the network logic are involved, this method has advantage that decisions required of the decision maker are simple, and can handle a large data or alternatives. Thus optimization techniques have been developed to aid in the quick determination of the minimum cost for every possible value of project duration. Clearly, the use of optimization techniques incorporated with time-cost trade-off becomes an economic necessity and the objective of this research.

In considering a linear programming algorithm for least cost, Selinger (1980) developed a dynamic programming model for linear project. His work ignored to incorporate the cost as decision variable in the optimization process. As an extension of the Selinger's work Russel and Caselton (1988) formalized a N-stage dynamic programming solutions into two state variable to determine the minimum project duration. In the optimization process, the developed model ignored the activities cost as a decision variable.

Reda (1990) developed a linear programming to identify minimum cost maintaining constant production rates and rates repetitive projects. This method could only be used for nontypical linear project and not applicable to construction activities were accomplished serially. In reality, most construction activities were accomplished concurrently while others were accomplished serially.

Elmaghraby and Pulat (1997) considered completion schedules on an arbitrary set of milestone events by developing an efficient algorithm to determine the project schedule which minimizes the sum of the total cost plus penalties for late completion. Another extension was by Moore et al., (1998) who used goal programme to consider multiple objectives, such as completion time, resources leveling and operation within a limited budget.

Senouci and Eldin (1996) presented a dynamic programming formulation for the scheduling of non sequential or nonserial activities to determine the project time-cost profile which determines possible project duration and their minimum project total cost. The formulation considered the effects of interruptions, minimum project direct cost, and minimum project duration.

To have a sound system of cost and time control of a construction project, (Gopalakrishan 2001), mathematical programming is becoming increasingly important. Linear programming uses a mathematical model to describe the problem of concern. It deals with the optimization of a linear objective function subject to a set of constraint conditions in the form of linear inequalities and/ or equations. Thus linear programming involves the planning of activities in order to obtain an optimal result, thus a result, which reaches the specified goal best among all feasible alternatives

Hasse K, (1994). A characteristic of many projects is that all work must be performed in some well-defined order.

Eppen and Martin, (1987). This formulation concerned the scheduling of the activities, which combined to make a project. The analysis requires a graphical illustration of the starting and ending times costs for each activity of the project are known. The linear programming formulation provided a means of selecting the least costly schedule for desired completion time.

Wilson (2003) explained that, linear programming analysis may be utilized to maximize a linear function subject to a finite number of linear constraints. In constructing the model, the objective function was to minimize the overall cost in order to reduce the completion time of construction projects. By solving the linear programming problem, the crash schedule and the corresponding crash cost can be found.

Zabelle (1998) said the objective function minimizes the sum of the total construction cost that occurs in all links of the system during all of the periods. Acting within the constraints and related costs, it was required to determine the crashing time for each activity, which will make the cost function a minimum.

Hynn et al. (1998), conducted a research on work-plan, that is, Database for work package and production scheduling, defined a work-plan as the first computer tool designed specifically to implement lean production philosophy in construction. According to them, work-plan guides the user step by step through the process of spelling out work packages, identifying constraints, checking constraints satisfaction, releasing work packages, and allocating resources; then at the end of the week, collecting field progress data and reasons for plan failure. This systematic approach helped the user create quality work plans and learn from understanding reasons for failure.

Womack and Jones (1996), in a related work, the application of lean production techniques in construction have been triggered by its success in manufacturing. A number of studies were conducted to date in order to refine the thinking process and to develop appropriate methods to implement lean construction. However, to our knowledge, no computer tools have yet been developed for field level-use.

Womack and Jones (1996) have been implemented in clear documenting, updating and constantly reporting the status of all process flows to all involved, so each person knows what others do and understands the implications of quality of their own work on the quality of the process output. Work-plan stores all work planning information in a database and generates relative information from it.

Ballard and Howell, (1997) said, synchronizing and physically aligning all steps in the production process, so there is little wait time for people or machines, and virtually no staging of partially completed products. Work-plan tries to eliminate unnecessary wait time on site by helping its users screen work packages. Releasing work packages only when all the resources are ready allows the construction to be carried out with minimum chance of being interrupted. As a result, fewer partially-completed work packages are being assigned to crews on site.

Zipkin (1991), proposed that stopping the assembly line to immediately repair quality defects. While this usually is very disruptive for the process as a whole, there are several advantages to doing so; thus the flawed processing step can be corrected right away, before numerous other assemblies have undergone the same treatment, resulting in additional defects, and it is substantially easier and less costly to discover and repair a quality defect early on in a process rather than at the end, after an assembly has been completed.

Bishop (1957); Bowman (1956), showed that the problem of balancing costs of overtime production and inventory storage to minimize the total cost of meeting given sales requirements can be set up as a transportation problem. Accordingly, Bowman suggested the use of the method of Charnes and Cooper for the solution.

Wolsey (1997), focusing on optimal control theory, extensive studies and analysis has been carried out on the production-inventory scheduling problems, using the optimal control methodology. The pioneering work by (Hwang et al., 1967) which modeled a simple problem of aggregate production planning in a continuous-time form had been acknowledged.

Bensoussan et al., (1983) considered both discrete and continuous time production scheduling problems, and within the continuous-time frame work, they considered both continuous and impulse control formulations. Sethi and Zhang (1995), Maimon et al. ,(1998).

Dauzere-Peres et al., (2000), carried out an extensive study on continuous-time production control models in deterministic and stochastic environments. The solution methodology was usually based on either Hamilton- Jacobi-Bellman dynamic programming or the Pontryagin maximum principle. For linear costs and simple demand functions (constant, cyclic, etc), the optimal production can be obtained in a closed form. For more complicated cases, development of specific numerical procedures is required.

Kilfgore Flares Co. LLC, supplier of decoy flares to the U.S. military, recently began using FEA based multiphysics software to trim manufacturing costs. FEA software from Algor Inc., Pittsburgh will help minimize material rejecting during production and improve flare reliability.

An important development in the modeling of planning and scheduling in process manufacturing has been the State-task Network (STN) representation introduced by Kondili etal.,(1993). The STN frame work uses materials (states) and tasks as building blocks for the process description, with each task consuming and producing materials while using equipment. An enhancement to the STN representation is the Resource –Task Network (RTN) proposed by Pantelides (1994) which unifies the treatment of both equipment and materials as resources that are consumed (produced) at the start (end) of a task.

Eppen and Martin (1987) classified lot sizing problems with finite planning periods into two models- small bucket and big bucket models. Small bucket models have relatively short periods.

In the small bucket model, at most one type of item can be produced and one setup can incur on the machine during each time period. Examples of this type of model are the Discrete Lot Sizing Problem (DLSP), and Continuous Lot Sizing Problem (CLSP). In DLSP, production must be at capacity if a machine is used to produce an item. In CLSP, the amount of production can vary, but is limited by the capacity of a machine. The solution of the small bucket problem contains production sequence of items on the machine. On the other hand, the big bucket model has fewer, but longer period without restriction on the number of items or setups per period and machine. In large bucket model, many different items can be produced on the same machine in one time period. Examples of large bucket models are the Capacitated Lot Sizing Problem (CLSP), and the General Lot Sizing and Scheduling Problem (GLSP).

Linear programming models were used in addressing production problems in sectors such as mining. The advantage of using linear programming for solving mine planning and scheduling problems have been recognized since the 1960s. Manula (1965), Kim (1967), Johnson (1969), Meyer (1969) and Ramani (1970) all addressed these problems using linear programming formulations. While a number of applications were performed over the next decade (Gangwar, 1973; Wike and Reimer, 1977; Smith, 1978), linear programming has not become the predominant method of mine scheduling.

Newman et al., (2006) LKAB's Kiruna Mine, located in northern Sweden, produced about twenty-four million of ore yearly using underground mining method known as sub-level caving. To aid in its ore mining and processing systems, Kiruna has adopted the use of several types of multi-period production scheduling models that have some distinguishing features such as specific governing the way in which the ore is extracted from the mine, lack of inventory holding policy and decisions that are not explicitly cost-based.

Dileep and Sumer (2007) presented a paper or an article that dealt with a multi-machine, multi-product lot size determination and scheduling problem. The model developed considered not only the usual inventory-related operational cost, but also the costs that depend on under-or-over utilized of available men and machines. It penalizes overtime or idle time at any facility. The solution minimizes the inventory and resource-related costs and not just inventory costs. A heuristic is developed to determine the solution from the model and to modify it, as necessary, to obtain a conflict-free, repetitive, and cyclic production schedule for an infinite horizon.

Hadjinicola and Kumar (2002) assumed that production costs vary linearly with product attributes and allowed for exchange rates, inventory costs and transportations in their analysis. However, the model does not include the supply segments of the supply chain, but considered only the end product manufacturing location for a set of markets.

Simpson (2005) in a recent paper said, Computer Integrated Manufacturing (CIM) had become the most practical production system. Nevertheless, some problems appear in the stage of scheduling that were affected by the complexity of the system. Especially, CIM was classified to be an on-line system that had to decide the production schedule within a very short period.

Silver et al.,(1998) said, nowadays, among the applied scheduling rules in CIMs, meta scheduling methods such as GA and SA have been widely used. Some meta scheduling methods were applied to a model of CIM that is to as an Automated Flow Shop, where backward scheduling should be used to realize a JIT's theory. The objective of such a function was to minimize the total cost calculated through the production schedules of orders. Scheduling methods were constructed and tested in the scheduling model by conducting the simulation test.

Lodree and Norman (2006) conducted a research relating to personnel scheduling, where the objective was to optimize system performance while considering human performance limitations and personnel well-being. They stated that the overall performance of a system was often directly related to how system personnel were scheduled. According to them, personnel are critical components of many systems. Properly considering human capability and the man-machine interface was essential in order to maximize system effectiveness. Topics such as work test scheduling, job rotation, cross training, and task learning and forgetting were considered.

Dessouky and Kijowski (1997) undertook a study that addressed the problem of scheduling a single –staged multi-product batch chemical process with fixed batch sizes. A mixed integer nonlinear programming model was used to determine the schedule of batches, the batch size and the number of overtime shifts that satisfy the demanded minimum cost. A polynomial –time algorithm was used to solve the problem when the processing times of all batches are identical and the set up and cleaning times are sequence-independent. The solution procedure was based on recognizing that optimal fixed batch sizes were a member of a set whose cardinality was polynomial. Given the batch size, the problem was formulated as a simplex algorithm problem, which is an assignment problem.

An open queuing network multiple product classes were considered by (Bitran et al., 1988). In each class, job routing was deterministic and arrival and service times were independent and identically distributed. The decomposition method for such systems were examined and shown to provide parameter estimates that are unacceptably inaccurate. This approach was enriched by modelling a previously ignored phenomenon, the interference among products. The performance of the decomposition methodology is significantly improved by recognizing the effect of interference.

Wien and Ou (1991) studied the relationship between dynamic job-scheduling problems and the assumptions made regarding processing times. Three such scheduling problems were analyzed using computer simulation. Seven scenarios, six stochastic and one deterministic were tested. Two policies were also examined; these are the Shortest Expected Processing Time (SEPT) rule and a Brownian analysis-derived rule. The research indicated that simulation results may mot translate in more realistic settings.

Motivated by semiconductors wafer fabrication, Wien and Ou (1991) considered a scheduling problem for a single –server multiclass queue. A single workstation fabricates semiconductor wafers according to a variety of different processes, where each process consists of multiple stages of service with a different general service time distribution at each stage. A batch (or lot) of wafers produced according to a particular process randomly yields of many different product types, and completed chips of each type enter a finished goods inventory that services exogenous customer demand for that type.

Shapiro (1993) and Smith (1956) showed that, the scheduling problem was to dynamically decide whether the server should be idle or working, and in the latter case, to decide which stage of which process to serve next. The objective was to minimize the long run expected average cost, which included for holding work-in process inventory (which may differ by process type and service stage) and backordering and holding finished goods inventory (which may differ by product type). They assumed that the workstation must be busy the great majority of the time in order to satisfy customer demand, and approximate the scheduling problem by control problem involving Brownian motion.

Bitran et al., (1992) studied production planning problems where multiple item categories were produced simultaneously. The items had random yields and were used to satisfy the demands of many products. These products had specification requirements that overlap. An item originally targeted to satisfy the demand of one product may be used to satisfy the demand of other products when it conforms to their specifications. Customers' demand must be satisfied from inventory hundred percent (100%) of the time. They formulated the problem with service constraints and provided near- optimal solution to the problem with fixed planning horizon. They also proposed simple heuristics for the problem solved with a rolling horizon. Some of the heuristics performed very well over a wide range of parameters.

Tempelmeier et al., (1996) said in coproduction systems, in which multiple products were produced simultaneously in a single production run, were prevalent in many industries. Such systems typically produced a random quantity of vertically differentiated products. This product hierarchy enabled the firm to fill demand for a lower-quality product by covering a higher-quality product. In addition to the challenges presented by random yields and multiple products, coproduction systems often serve multiple customer classes that differ in their product valuations. Furthermore, the sizes of these classes are uncertain. Employing a utility-maximizing customer model, Brian et al, (2008) investigated the production, pricing, down-conversion, and allocation decisions in a two-class, stochastic-demand, and stochastic-yield coproduction system.

For the single-class case, Brian and Yimin (2008) established that down-conversion will not occur if prices are set optimally. In contrast, they showed that down-conversion can be optimal in the two-class case, even if prices were set optimally. They considered the benefit of positioning certain operational decisions, e.g., the pricing or allocation-rule decisions, until uncertainties were resolved. They used the term recourse to denote actions taken after uncertainties have been resolved. They found that recourse pricing benefits the firm much more than either down-conversion or recourse allocation do, implying that recourse demand management is more valuable than recourse supply management. Special class of our model includes the single-class and tow-class random-yield newsvendor models.

Arthur and Yehuda (1999), presented and solved a single-period, multiproduct, downward substitution model. Their model had one raw material as the production input and produces N different products as outputs. The demands and yields for the products were random. They determined the optimal production input and allocation of the N products to satisfy demands. The problem was modelled as a two-stage stochastic program, which they showed can be decomposed into a parameterized network flow problem.

2.2 Summary

The chapter outlined and discussed the various research works and studies that were undertaken by researchers on single and multi-product system problems. It also outlined the various algorithms used in addressing production problems including linear and non linear programming methods. It again looked at overtime and inventory related-costs, and their implication on production in achieving optimality. Different production problems identified and models developed to minimize these production problems.

The next chapter will consider the modelling of production problem into a transportation problem, which can be solved easily.

CHAPTER 3

METHODOLOGY

3.0 THE TRANSPORTATION PROBLEM

Transportation method is a simplified version of the simplex technique that may be used to solve a type of linear programming problem. Because of its major application in solving problems involving several product sources and several destinations of products, this type of problem is frequently called the transportation problem. It obtains its name from its application to problems involving transporting products from several sources to several destinations. The transportation model seeks the determination of transporting/shipping for a single commodity from a number, *m* of sources and a number, *n* of destinations. The formation can be used to represent more general assignment and scheduling objectives of such problems are either (1) minimize the cost of shipping *m* units to *n* destinations or (2) maximize the profit of shipping *m* units to *n* destinations.

Assuming there are *m* sources, each of which has available $a_i\ (i = 1, 2, \ldots, m)$ units of a homogeneous product supplying *n* destinations, each of which requires $b_j\ (j = 1, 2, \ldots, n)$ units of this product. The numbers a_i and b_j are positive integers. The cost c_{ij} of transporting one unit of product from the i^{th} source to the j^{th} destination is given for each i and j .

Source capacities, destinations requirements and costs of material shipping from each source to each destination are given constantly. Thus it is assumed that total supply and total demand are equal; that is

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Let x_{ij} represent the (unknown) number of units to be shipped from source i to destination j. Then the standard mathematical model for this problem is

Minimize:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij}$$

Subject to:

$$\sum_{j=1}^{n} x_{ij} \leq a_i, i = 1, 2, \dots, m \qquad \dots. \dots. \dots. (1)$$

$$\sum_{i=1}^{m} x_{ij} \geq b_j, j = 1, 2, \dots, n \qquad \dots. \dots. \dots. (2)$$

$$x_{ij} \geq 0, 1 \leq i \leq m, 1 \leq j \leq n$$

where

m … number of sources (month of production)

n … number of destinations (month of distribution)

a_i … capacity of i-th source (in, Ghana cedis, hectoliters, etc)

b_j …demand of j-th destinations (in, Ghana cedis, hectoliters, etc)

c_{ij} … cost coefficients of material shipping (unit shipping cost) between i-th source and j-th destination.

x_{ij} … amount of material shipped between i-th source and j-th destination (in, Ghana cedis, hectoliters etc.)

3.1 THE TRANSPORTATION TABLEAU

The transportation tableau, where supply availability at each source is shown in the far right column and the destination requirements are shown in the bottom row. Each cell represents one route. The unit shipping cost is shown in the upper right corner of the cell, the amount of shipped material is shown in the center of the cell.

Table 3.1 The Transportation Tableau

	W_1	W_2	W_3	. . . .	W_n	Supply
S_1	C_{11} X_{11}	C_{12} X_{12}	C_{13} X_{13}	. . . .	C_{1n} X_{1n}	a_1
S_2	C_{21} X_{21}	C_{22} X_{22}	C_{23} X_{23}	. . . .	C_{2n} X_{2n}	a_2
.						.
.						.
S_m	C_{m1} X_{m1}	C_{m2} X_{m2}	C_{m3} X_{m3}	. . . .	C_{mn} X_{mn}	a_m
Demand	d_1	d_2	d_3	. . . .	d_n	

3.2 BALANCED TRANSPORTATION PROBLEM

If total supply equals to total demand, the problem is said to be a balanced transportation problem: that is $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

Methods to find the Balanced Transportation Problem

If total supply equals to total demand, the problem is said to be a balanced transportation problem: that is $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

Balancing a Transportation Problem if total supply exceeds total demand

If total supply exceeds total demand, we can balance the problem by adding dummy fictitious demand point. Since shipments to the dummy demand point are not real, they are assigned a cost of zero.

Balancing a transportation problem if total supply is less than total demand

If a transportation problem has a total supply that is strictly less than total demand the problem has no feasible solution. There is no doubt that in such a case one or more of the demand will be left unmet. Generally in such situations a penalty cost is often associated with unmet demand and as one can guess this time the total penalty cost is desired to be minimum.

3.3 THE SOLUTION METHOD

The transportation problem can be described using linear programming mathematical model and usually it appears in a transportation tableau. There are three general steps in solving transportation problems.

At first, it is necessary to prepare an **initial feasible solution**, which may be done in several different ways; the only requirement is that the destination needs be met within the constraints of source supply. The transportation algorithm is the simplex method.

It involves

i. finding an initial, basic feasible solution;
ii. testing the solution for optimality;
iii. improving the solution when it is not optimal
iv. repeating steps (ii) and (iii) until the optimal solution is obtained.

3.4 METHODS OF FINDING INITIAL BASIC FEASIBLE SOLUTION FOR TRANSPORTATION PROBLEM.

Unlike other Linear Programming problems, a *balanced* Transportation Problem with *m* supply points and *n* demand points is easier to solve, although it has $m + n$ equality constraints. The reason for that is, if a set of decision variables *(x_{ij}'s)* satisfy all but one constraint, the values for x_{ij}*'s* will satisfy that remaining constraint automatically. Initial allocation entails assigning numbers to cells to satisfy supply and demand constraints.

Methods to find the initial basic feasible solution for a balanced Transportation Problem

There are three basic methods:

- The Northwest Corner Method

- The Least Cost Method
- The Vogel's Approximation Method

3.4.1 The Northwest Corner Method

To find the initial basic feasible solution by the North West Corner method:

Step 1: Begin in the upper left (or northwest) corner of the transportation tableau and set x_{11} as large as possible. Clearly, x_{11} can be no larger than the smaller of s_1 and d_1.

Step 2: If $x_{11} = s_1$, cross out the first row of the transportation tableau; this indicates that no more basic variables will come from row 1. Also change d_1 to $d_1 - s_1$.

Step 3: If $x_{11} = d_1$, cross out the first column of the transportation tableau; this indicates no more basic variables will come from column 1. Also change s_1 to $s_1 - d_1$.

Step 4: If $x_{11} = s_1 - d_1$, cross out either row 1 or column 1 (but not both). If you cross out row 1, change d_1 to 0; if you cross out column 1, change s_1 to 0.

Step 5: Continue applying this procedure to the most northwest cell in the tableau that does not lie in a crossed-out row or column. Eventually, you will come to a point where there is only one cell that can be assigned a value. Assign this cell a value equal to its row or column demand, and cross out both the cell's row and column. A basic feasible solution has now been obtained.

3.4.2 The Least Cost Method

The Northwest Corner Method does not utilize shipping costs. It can yield an initial basic feasible solution easily but the total shipping cost may be very high. The least cost method uses shipping costs in order to come up with a basic feasible solution that has a lower cost. To begin the minimum cost method,

Step 1: find the decision variable with the smallest shipping cost x_{ij}. Then assign x_{ij} its largest possible value, which is the minimum of s_i and d_j.

Step 2: cross out row i and column j and reduce the supply or demand of the non-crossed-out row or column by the value of x_{ij} .

Step 3: choose the cell with the minimum cost of shipping from the cells that do not lie in a crossed-out row or column.

Step 4: repeat the procedure in step 2 and step 3.

3.4.3 The Vogel's Approximation Method

Step 1: Begin with computing each row and column a penalty. The penalty will be equal to the difference between the two smallest shipping costs in the row or column.

Step 2: Identify the row or column with the largest penalty.

Step 3: Find the first basic variable which has the smallest shipping cost in that row or column.

Step 4: assign the highest possible value to that variable, and cross-out the row or column as in

Step 5: Compute new penalties and use the same procedure.

3.5 COMPUTING TO OPTIMALITY

There are two methods, namely

- The stepping stone method
- The modified distribution method

These are initial basic feasible solution to compute to optimality.

3.5.1 The Steppingstone Method

Step 1: Pick any empty cell and identify the closed path leading to that cell. A closed path consists of horizontal and vertical lines leading from an empty cell back to itself (If assignments have been made correctly, the matrix has only one closed path for each empty cell.) In the closed path there can only be one empty cell that we are examining. The 90-degree turns must therefore occur at those places that meet this requirement.

Step 2: Move one unit into the empty cell from a filled cell at a corner of the closed path and modify the remaining filled cells at the other comers of the closed path to reflect this move. (More than one unit could be used to test the desirability of a shift. However, since the problem is linear, if it is desirable to shift one unit, it is desirable to shift more than one, and vice versa.)

Modifying entails adding to and subtracting from filled cells in such a way that supply and demand constraints are not violated. This requires that one unit always be subtracted in a given row or column for each unit added to that row or column.

Step 3: Determine desirability of the move. This is easily done by (1) summing the cost values for the cell to which a unit has been added, (2) summing the cost values of the cells from which a unit has been subtracted, and (3) taking the difference between the two sums to determine if there is a cost reduction. If the cost is reduced by making the move, as many units as possible should be shifted out of the evaluated filled cells into the empty cell. If the cost is increased, no move should be made and the empty cell should be crossed.

Step 4: Repeat Steps 1 through 3 until all empty cells have been evaluated.

3.5.2 The Modified Distribution Method (MODI)

Modified method / Modi method / U-V method is the method for determining whether a basic feasible methods is optimal.

The steps involved in the method are as follows :

Step 1: Under this method we construct penalties for rows and columns by subtracting the least value of row / column from the next least value.

Step 2: We select the highest penalty constructed for both row and column. Enter that row / column and select the minimum cost and allocate min (a_i, b_j)

Step 3: Delete the row or column or both if the rim availability / requirements is met.

Step 4: We repeat steps 1 to 3 till all allocations are over.

Step 5: For all allocation form equation $u_i + v_j = c_j$, set one of the dual variable u_i / v_j to zero and solve for others.

Step 6: Use these values to find $k_{ij} = c_{ij} - u_i - v_j$. If all ij = 0, then it is the optimal solution.

Step 7: If any k_{ij} = 0, select the most negative cell and form loop. Starting point of the loop is +ve and alternatively the other corners of the loop are –ve and +ve. Examine the quantities allocated at –ve places. Select the minimum. Add it at +ve places and subtract from –ve place.

Step 8: Form new table and repeat steps 5 to 7 till k ij = 0

Table 3.6

	W_1	W_2	W_3	. . . .	W_n	Supply
S_1	C_{11} X_{11}	C_{12} X_{12}	C_{13} X_{13}	. . . .	C_{1n} X_{1n}	a_1
S_2	C_{21} X_{21}	C_{22} X_{22}	C_{23} X_{23}	. . . .	C_{2n} X_{2n}	a_2
.						.
.						.
S_m	C_{m1} X_{m1}	C_{m2} X_{m2}	C_{m3} X_{m3}	. . . .	C_{mn} X_{mn}	a_m
Demand	d_1	d_2	d_3	. . . .	d_n	

m … number of sources (months of production)

n … number of destinations (months of distribution)

a_i … capacity of *i-th* source (in, Ghana cedis, hectoliters, etc)

b_j … demand of *j-th* destination (in, Ghana cedis, hectoliters, etc.)

c_{ij} … unit material shipping cost between *i*-th source and *j-th* destination (in cedis or as a distance in kilometers, miles, etc.)

x_{ij} … amount of material shipped between *i*-th source and *j-th* destination (in, Ghana cedis, hectoliters etc.)

Let an initial basic feasible solution be available. Then (*m+n-1*) cells are occupied.

Test for optimality

For each occupied cell (i,j) of the transportation tableau, compute a row index u_i and a column index v_j such that $c_{ij} = u_i + v_j$

Since there are *(m+n-1)* occupied cells, it follows that there are m + n -1 of these equations.

Since there are (*m + n)* row and column in dices altogether,it follows that by prescribing an arbitrary value for one of them,we say u=0,we then solve the equations for the remaining (*m+n - 1)* unknowns u_i, v_j.

With all the u_i, v_j known,we compute for each unoccupied cell such that the evaluation factor e_{st} is computed as

$$e_{st} = c_{st} - u_s - v_j$$

It can be shown that the evaluation factors are the relative cost factors corresponding to the non-basic variables when the Simplex method is applied to the transportation problem. Hence the current basic feasible solution is optimal if and only if $e_{st} > 0$ for all unoccupied cells (s,t),since the transportation problem is a minimization problem. If there are unoccupied cells with negative evaluation factor, then current basic feasible solution is not optimal and needs to be improved.

Improvement to optimality

To improve upon the current basic feasible solution we find the unoccupied cell with the most negative evaluation factor, construct its circuit and adjust the value of the allocation in the cells of the circuit in exactly the same way as done in the steppingstone method. This yields a new basic feasible solution available; the whole process is repeated until optimality is attained.

Remarks

The fact that the circuit is not constructed for every unoccupied cell makes the modified distribution method more efficient than steppingstone method. In fact the MODI method is currently the most efficient method of solving the transportation problem.

If the total supply exceeds the total demand

If the total supply exceeds the total demand, we create a fictitious warehouse w_F whose demand is precisely the excess of supply over demand and such that the unit cost each source to the fictitious warehouse w_F is zero.

If the total demand exceeds total supply

if the total demand exceeds total supply, create a fictitious source Sf whose capacity is precisely the excess of demand over supply and such that the unit cost from source to every warehouse is 0.

How to Pivot a Transportation Problem

Based on the transportation tableau, the following steps should be performed.

Step 1. Determine (by a criterion to be developed shortly, for example northwest corner method) the variable that should enter the basis.

Step 2. Find the loop (it can be shown that there is only one loop) involving the entering variable and some of the basic variables.

Step 3. Counting the cells in the loop, label them as even cells or odd cells.

Step 4. Find the odd cells whose variable assumes the smallest value. Call this value θ. The variable corresponding to this odd cell will leave the basis. To perform the pivot, decrease the value of each odd cell by θ and increase the value of each even cell by θ. The variables that are not in the loop remain unchanged. The pivot is now complete. If θ=0, the entering variable will equal 0, and an odd variable that has a current value of 0 will leave the basis. In this case a degenerate basic feasible solution existed before and will result after the pivot. If more than one odd cell in the loop equals θ, you may arbitrarily choose one of these odd cells to leave the basis; again a degenerate basic feasible solution will result.

3.6 DEGENERACY

Degeneracy exists in a transportation problem when the number of filled cells is less than the number of rows plus the number of columns minus one (m + n - 1). Degeneracy may be observed either during the initial allocation when the first entry in a row or column satisfies both the row and column requirements or during the Stepping stone method application, when the added and subtracted values are equal. Degeneracy requires some adjustment in the matrix to evaluate the solution achieved. The form of this adjustment involves inserting some value in an empty cell so a closed path can be developed to evaluate other empty cells. This value may be thought of as an infinitely small amount, having no direct bearing on the cost of the solution.

Procedurally, the value (often denoted by the Greek letter epsilon), is used in exactly the same manner as a real number except that it may initially be placed in any empty cell, even though row and column requirements have been met by real numbers.

Once has been inserted into the solution, it remains there until it is removed by subtraction or until a final solution is reached.

While the choice of where to put an ε is arbitrary, it saves time if it is placed where it may be used to evaluate as many cells as possible without being shifted.

How to Overcome Degeneracy

(i) Add zero(s) to make up the (m+n-1) basic variables.

(ii)Add zero(s) in such a way that no circuit is formed.

3.7 THE PRODUCTION PROBLEM

The production problem is similar to the transportation problem except that in the production problem, it is possible to both ships into and out of the same node (point). It is an extension of the transportation problem in which intermediate nodes, referred to as transshipment nodes, are added to account for locations such as warehouses. In this more general type of distribution problem, shipments may be made between any three pairs of the three general types of nodes: origin nodes, transhipment nodes and destination nodes. for example transhipment problems permits shipments of goods from origins to transhipment nodes and on to destinations, from one origin to another origin, from one transhipment location to another, from one destination location to another and directly from origins to destinations.

The general linear programming model of a production problem is

Minimize

$$\sum_{allarcs} c_{ij} x_{ij}$$

Subject to:

$$\sum_{arcout} x_{ij} = \sum_{arcin} x_{ij} \leq s_i$$

Origin nodes i …. …. (1)

$$\sum_{arcsout} x_{ij} - \sum_{arcin} x_{ij} = 0$$

Production nodes …. ….(2)

$$\sum_{arcin} x_{ij} - \sum_{arcout} x_{ij} = d_j$$

Destination nodes j …. ….(3)

Where

x_{ij} = number of units shipped from the node i to node j

c_{ij} = cost per unit of shipping from node i to node j

s_i = supply at origin node i

d_{ij} = demand at origin node j

For the transportation problem, you can ship only from supply points to demand points. For the transhipment problem, you can ship from one supply point to another or from one demand point to another. Actually, designating nodes as supply points or demand points becomes confusing when you can ship both into and out of a node. You can make the designations clearer if you classify nodes by their net stock position-excess (+), shortage (-), or 0.

One reason to consider transportation is that units can sometimes be shipped into one city at a very low cost and then transhipped to other cities. In some situations, this can be less expensive than direct shipment. The main objective in the transportation problem is to determine how many units should be shipped over each arc in the network so that all destination demands are satisfied with the minimum possible transportation cost.

Model

There are two possible conversions to a transportation model. In the first conversion, make each excess node a supply point and each shortage node a demand point. Then, find the cheapest method of shipping from surplus nodes to shortage nodes considering all transportation possibilities.

The second conversion of a transportation model does not require finding all of the cheapest routes from excess nodes to shortage nodes. The second conversion requires more supply and demand nodes than the first conversion, because the points where you can ship into and out of occur in the converted transportation problem twice – first as a supply point and second as a demand point.

3.8 CONCLUSION

The transportation problem is only a special topic of the linear programming problems. It would be a rare instance when a linear programming problem would actually be solved by hand. There are too many computers around and too many LP software programs to justify spending time for manual solution. An Excel Solver software will be used to analyze the data. (There are also programs that assist in the construction of the LP or TP model itself. Probably the best known is GAMS—General Algebraic Modeling System (GAMS-General, San Francisco, CA). This provides a high-level language for easy representation of complex problems.

3.9 SUMMARY

In this chapter, the transportation and production problems were presented. In the next chapter, I shall put forward data collection and data analysis of my work

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.0 INTRODUCTION

This chapter deals with data collection, data analysis and discussion, the discussion of the results obtained from production scheduling of GGBL.

The data was acquired by introducing a questionnaire at the GGBL production department. The questionnaire sought to find out the regular and over time production for Malta Guinness. The data used for the analysis is from July 2008 to June 2009.

Guinness Ghana Brewing Limited, Kaase Kumasi, being a production firm must determine the quantity of goods to produce during each of the next twelve month in order to meet given demand. Guinness Ghana Brewing Limited, Kaase produces both alcoholic and non alcoholic beverages. The alcoholic beverages include Guinness, Star, Gulder, Heineken and Smirnoff. The non alcoholic beverages include Malta Guinness, Amstel Malta, Malta Guinness Quench and their new beverage, Alvaro.

The data was obtained from GGBL Production unit; the cost of transporting goods involves fuel consumption of vehicle, cost of labour and maintenance. The sources of raw materials are called "malt beer", the warehouses are called "the ultra modern brewing department, a modern and highly automated Packaging unit and distribution operations", and the final destination is the industry. There are three main sources of raw materials, namely:

The young beer or wheat soda drink which is carbonated malt beverage which is brewed from barley.

Nowadays, most Malta is brewed in the Caribbean areas, Ghana, Nigeria, Panama etc. Malta originated in Germany, known as Malzbier (malt beer), which is a Malty dark beer whose fermentation is interrupted at approximately 2%.

The data shows the production of Malta Guinness from July 2008 to June 2009.

4.1 Computational Procedure and Data Analysis

The company brews and package the Malta Guinness into bottles. The bottle contains 300ml of Malta Guinness and is packaged in cases. A case contain 24 bottles , each with total volume of 0.072 hectolitres

Table 4.1 represent the company's production capacities and expected demands for one of its product, which is Malta Guinness from July 2008 to June 2009.

Table 4.1 Production Capacity of Malta Guinness (in hectolitres)

Months	Demand	Regular Capacity	Overtime Capacity
July	11160	14832	7416
August	22608	19440	9720
September	10296	16848	8424
October	23040	23042	11520
November	20592	20160	10080
December	13032	15840	7920
January	25272	21600	10800
February	14688	20160	10080
March	22032	23184	11592
April	13536	17280	8640
May	9288	23040	11520
June	15336	17280	8640
Total	200880	232670	123552

source: Kumasi Brewery Limited, Production unit .

The first column deals with months within which the data were collected, thus from July 2008 to June 2009. The second column describes the demand amount that must be produced to meet the request made by their client. The highest demand was recorded in the month of January. The lowest demand was recorded in the month of May. The total demand and the average demand were 200880 and 16740 respectively.

The third column shows the regular capacity which is the amount of Malta Guinness produced during the normal working hours. The highest regular capacity was recorded as 23184 whiles the lowest regular capacity was recorded as 14832. The total regular production capacity was 232670 with an average capacity of 19389.

The fourth column which is the overtime capacity is the amount of Malta Guinness produced aside the normal working hours. The highest overtime capacity was 11592 and the lowest overtime capacity was 7416. The total overtime capacity was also recorded as 123552 with an average overtime capacity as 10296.

The production capacities and demand are converted to cases in figures in Table 4.2 by multiplying each of the figures in Table 4.1 by 0.072 hectolitres to obtain the figures in Table 4.2

Table 4.2 Production Capacity (in Cases)

Months	Demand	Regular Capacity	Overtime Capacity
July	155000	206000	103000
August	314000	270000	135000
September	143000	234000	117000
October	320000	320000	160000
November	286000	280000	140000
December	181000	220000	110000
January	351000	300000	150000
February	204000	280000	140000
March	306000	322000	161000
April	188000	240000	120000
May	129000	320000	160000
June	213000	322000	161000

Table 4.4 Optimal Production Tableau

Months	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Dummy	Supply
Inventory	0 120000	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	0	120000
Regular July	10000	14 206000	14.25	14.5	14.75	15	15.25	15.5	15.75	16	16.25	16.5	0	206000
Regular Aug	10000	10000	14 143000	14.25	14.5	14.75	15	15.25	15.5	15.75	16	16.25	0 127000	270000
Regular Sept	10000	10000	10000	14 234000	14.25	14.5	14.75	15	15.25	15.5	15.75	16	0	234000
Regular Oct	10000	10000	10000	10000	14 286000	14.25	14.5	14.75	15	15.25	15.5	15.75	0 34000	320000
Regular Nov	10000	10000	10000	10000	10000	14 181000	14.25	14.5	14.75	15	15.25	15.5	0 99000	280000
Regular Dec	10000	10000	10000	10000	10000	10000	14 220000	14.25	14.5	14.75	15	15.25	0	220000
Regular Jan	10000	10000	10000	10000	10000	10000	10000	14 204000	14.25	14.5	14.75	15	0 96000	300000
Regular Feb	10000	10000	10000	10000	10000	10000	10000	10000	14 280000	14.25	14.5	14.75	0	280000
Regular Mar	10000	10000	10000	10000	10000	10000	10000	10000	10000	14 188000	14.25	14.5	0 134000	322000
Regular Apr	10000	10000 -	10000	10000	10000	10000	10000	10000	10000	10000	14 129000	14.25	0 111000	240000
Regular May	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	14 213000	0 107000	320000
Regular Jun	14 35000	14.25	14.5	14.75	15	15.25	15.5	15.75	16	16.25	16.5	10000	0 287000	322000
Overtime July	14.22 0	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000		0 103000	103000

Overtime Aug	10000	10000	14.22 108000	1000	10000	10000	10000	10000	10000	10000	10000	10000	0 27000	135000
Overtime Sept	10000	10000	10000	14.22 0	10000	10000	10000	10000	10000	10000	10000	10000	0 11700	117000
Overtime Oct	10000	10000	10000	10000	14.22 86000	10000	10000	10000	10000	10000	10000	10000	0 74000	160000
Overtime Nov	10000	10000	10000	10000	10000	14.22	10000	10000	10000	10000	10000	10000	0 140000	140000
Overtime Dec	10000	10000	10000	10000	10000	10000	14.22	1000	10000	10000	10000	10000	0 110000	110000
Overtime Jan	10000	10000	10000	1000	10000	10000	10000	14.22 131000	10000	10000	10000	10000	0 19000	150000
Overtime Feb	10000	10000	10000	10000	10000	10000	10000	10000	14.22	10000	10000	10000	0 140000	140000
Overtime Mar	10000	10000	10000	10000	10000	10000	10000	10000	10000	14.22 26000	10000	10000	0 135000	161000
Overtime Apr	10000 10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	14.22	10000	0 120000	120000
Overtime May	10000	10000 10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	14.22	0 160000	160000
Overtime Jun			10000	10000	10000	10000	10000	10000	10000	10000	10000	1000	0 161000	161000
Demand	155000	314000	143000	320000	286000	181000	351000	204000	306000	188000	129000	213000		

Production cost of Malta Guinness is made up of brewing materials, packaging materials cost and utilities. Production is carried out throughout the day i.e. 24 hours, in three shifts of 8 hours per shift. At the beginning of each month, the company must decide many products should be produced during the current month.

The regular production cost per case is GH¢14.00 and the overtime cost per case is GH¢14.22. Generally, goods produced are not available for transport during time of production; they are sold during the following month. Those that are not are added to inventory are carried forward at a cost of GH¢0.25 per case for one month.

Regular production cost per case for each of the month is GH¢14.00. For simplicity, we assume that goods used during each month would be used to meet demand for the current month.

Since the company operates 24 hours a day by running shift, overtime is considered as being part of the regular working hours. By having employees work overtime during a month. The unit cost of overtime per case is GH¢14.22.

The company has an inventory of 120,000 cases as at the beginning of July 2008.

Units produced on regular shifts are not available for shipments during production, they are generally sold during the next month. Those that are not, are added to inventory and carried forward at an average holding cost of GH¢0.25 per case every month, on the other hand, unit produced during overtime shifts must be added to meet demand in the same month as produced.

It was observed that, the company will incur an overall total regular production cost of GH¢ 46,396,000 and overtime cost of GH¢23, 562,540 during the production period. This means that, an overall production and overtime cost of GH¢69,958,540 will be incurred in producing 2,790,000 bottles of Malta Guinness to meet demands of its customers.

Applying the transportation problem to the resulting tableau, we solve the production problem using the transportation problem to minimize the sum of production and inventory cost during the next twelve month.

4.2 Computational Procedure

A Core i3 Toshiba Satellite laptop was used for the data presentation and the analysis. The model was Inter ® Core ™ i3 CPU with a speed of 4 gigabytes. It has a hard disk size of 500 gigabytes with Random Access Memory of 4 gigabytes.

An excel solver was used to analysed the data. The algorithm was run once to obtain the maximum cost of production as GH¢4004000. The minimum cost of production was

GH¢490000.

The total cost shipment was GH¢ 32021220. The average cost of shipment was GH¢914892.

The total shipment was 5191000 units. The maximum shipment was 287000 units with a minimum shipment of 19000 units.

The average shipment was 148314 units.

4.3 Results

Table 4.3.1 Production Tableau (Result from the Excel Solver).

Production Months (Source)	Supply months (Destination)	Shipment	Unit cost (GH₵)	Cost (GH ₵)
Source 1	Destination 2	206000	14	2884000
Source 2	Destination 3	143000	14	2002000
Source 2	Dummy	127000	0	0
Source 3	Destination 4	234000	14	3276000
Source 4	Destination 5	286000	14	4004000
Source 4	Dummy	34000	0	0
Source 5	Destination 6	181000	14	2534000
Source 5	Dummy	99000	0	0
Source 6	Destination 7	220000	14	3080000
Source 7	Destination 8	204000	14	2856000
Source 7	Dummy	96000	0	0
Source 8	Destination 9	280000	14	3920000
Source 9	Destination 10	188000	14	2632000
Source 9	Dummy	134000	0	0
Source 10	Destination 11	129000	14	1806000
Source 10	Dummy	111000	0	0
Source 11	Destination 12	213000	14	2982000
Source 11	Dummy	107000	0	0
Source 12	Destination 13	35000	14	490000
Source 12	Dummy	287000	0	0
Source 13	Destination 14	120000	0	0
Source 14	Dummy	103000	0	0
Source 15	Destination 16	108000	14.22	1535760
Source 15	Dummy	27000	0	0
Source 16	Dummy	117000	0	0
Source 17	Destination 18	86000	14.22	1222920
Source 17	Dummy	74000	0	0
Source 18	Dummy	140000	0	0
Source 19	Dummy	110000	0	0
Source 20	Destination 21	131000	14.22	1862820
Source 20	Dummy	19000	0	0
Source 21	Dummy	140000	0	0
Source 22	Destination 23	26000	14.22	369720
Source 22	Dummy	135000	0	0
Source 23	Dummy	120000	0	0
Source 24	Dummy	160000	0	0
Source 25	Dummy	161000	0	0
Total		5191000		32021220

Analysis of results generated from the excel solver is presented below.

It was observe that the level of demand at each destination has been determined and the total demand was given as 2,790,000 units.

Also the level of supply at each source has been determined and the total supply was given as 2,790,000 units.

Then 35,000 units produced in June; regular production and the inventory of 120,000 were used to supply the demand for July.

The regular production of 206,000 units in July and108, 000 units from overtime production in August was used to supply the demand for the month of August.

The regular production of 143,000 units was fully used to serve the demand for September.

The demand for October was met by 234,000 units produced during regular production in September and 86,000 units from overtime production in October.

The demand for November was met by 286,000 units from the regular production in October.

The demand for December was met by 181,000 units from the regular production from in November.

All 220,000 units produced during regular production in December and 131,000 units from overtime in January are used to satisfy demand in January.

The demand in February was met by 204,000 units from the regular production in January.

All 280, 000 units produced during regular production in February and 26,000 units from overtime are used to satisfy demand in March.

The regular production of 188,000 units from March was used to satisfy demand in April.

The regular production of 129,000 units from April was used to satisfy demand in May.

The regular production of 213,000 units from May was used to satisfy demand in June.

From the results, it is clear that, the overtime production for July, September, November, December, February, April, May and June are not necessary that the management can do away with them to save cost.

Table 4.3.2 Production Tableau

Month (source)	Shipment (units)	Unit cost (GH¢)	Cost (GH¢)
July	206000	14	2884000
August	143000	14	2002000
September	234000	14	3276000
October	286000	14	4004000
November	181000	14	2534000
December	220000	14	3080000
January	204000	14	2856000
February	204000	14	2856000
March	204000	14	2856000
April	280000	14	3920000
May	188000	14	2632000
June	129000	14	1806000
July	213000	14	2982000
August	35000	14	490000
September	108000	14.22	1535760
October	86000	14.22	1222920
November	131000	14.22	1862820
December	26000	14.22	369720
Total	3078000		GH¢37457220

The implication of this finding is that the company could have drastically reduced its total production and inventory cost by GH¢32,501,320 or 46%. In actual fact, the company would have incurred an overall cost of GH¢ 69,958,540.

4.4. Discussions

Time periods during which production can take place are the regular shifts and overtime shifts for each of the twelve months. Since each of these twelve months periods becomes a source, we then add a thirteenth source, i.e. the initial inventory, since it can also supply goods.

Time periods in which products will be required or demanded are the twelve months. These become the destinations, with a total demand of 2,790,000 units.

Costs associated with the initial inventory are future carrying cost only, since production costs and past carrying charges have already been incurred and cannot be minimized. The remaining cost entries are simply the production cost plus storage charges.

Once there is a limit on the overtime production during each quarter, it is not clear what value should be chosen for the supply at each overtime production point. Since total demand for the year equals 2,790,000 units.

Any unused overtime capacity will be "shipped" to the dummy demand point. To ensure that no goods are used to meet demand during a month prior to their production, a prohibitively large cost (say GH¢ 10,000) is assigned to any cell that corresponds to using regular production to meet demand for a current or an earlier (or previous) month. In the same way, since units produced during overtime shifts must be used to meet demands in the same month as produced, a prohibitively large cost is also assigned to a cell that corresponds to using overtime production to meet next month's demand. Combining these observations yields the balanced production problem and its optimal solution in the table below.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Summary of Findings

The fact that companies can use efficient scheduling system to reduce production cost and inventory cost at the same time also satisfies that customer's demand is evident in the analysis drawn in the previous chapter. With efficient scheduling, the company was able to reduce the production cost and inventory cost 46% by scheduling. As a result of this the company was able to save more money and resources.

Furthermore, the three primary goals of production system were achieved. The first goal which involves due date and avoiding late completion of jobs was achieved as unnecessary overtime production was avoided. Then the second goal which involves through put times was achieved as the time a job spent in a system was minimized. And also the third objective which concerns the utilization of work centre would also be achieved as costly equipment and personnel would be fully utilized in order to minimize production and inventory cost. With this, it can be showed that the transportation program used can be used to schedule production activities efficiently. This goes to support the fact that computerized scheduling tools outperform older manual scheduling methods.

The study also revealed that efficient scheduling system and control can facilitate the production processes in a number of ways. First and foremost, scheduling system can result in optimum utilization of capacity. Thus companies, with the help of good production schedule system, can schedule their task and production in a way to ensure that production capacities i.e., employees and machinery do not remain idle, they should be fully utilized and that there is no undue queuing up of task since there is proper allocation of task to the production facilities.

It was also observed that proper production scheduling system can result in the reduction of cycle time and increase the turnover.

Significantly, the study revealed that a good production scheduling system ensures quality in terms of production processes, products and packaging. Thus it provides adherence to quality standards thereby ensuring overall quality output. With scheduling, companies would have adequate time to package the finished goods for prompt delivery.

5.2 Conclusion

The company was able to minimize production cost because of the introduction of the overtime production work schedule of the work plan of the workers by 46%.

During the production process for instance, the initial inventory, together with goods produced during regular production in June was used to meet demands in July. So to large a extent, a certain level of inventory is necessary. Production scheduling by the company can also ensure that the right supplies are available at the right time.

Again, production scheduling can bring about proper management of inventory. Thus proper production scheduling and control will assist the company to resort to just-in-time systems and thereby reducing the overall inventory. But too little inventory means an insufficient quantity of produce to meet the demand of consumers, in which case customers may defect to other firms.

Critically, it can be said that system and control is of immense value to the company in the area capacity utilization, inventory control and importantly, improving the company's response to time and quality. As such effective scheduling system and control contributes to time, quality and cost parameters of a company's success. Should companies adopt this type of production scheduling system, a lot of savings will be made and this can be added as working capital.

5. 3 Recommendation

Further work on how motivation of employees affects production cost. This suggest that the company should not necessarily maintain a large working or labour force for its production activities as the level of demand must always be the same as the level of supply, for it has been shown that for a balance production the demand should be equal to the supply.

It was also observed that all orders were attended to and no employee was idle. Overtime production scheduling should not be carried throughout the year unless it is to meet specific orders. Otherwise the company would have to stick to the regular production time to meet all orders. Since companies would have to pay higher wages to workers engaged in overtime production, ensuring optimum utilization of human capacity during regular production and of course with efficient machines, company would end up saving money and resources.

I therefore recommend that companies apply scheduling in their production processes in order to achieve optimal production and inventory cost.

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APPENDIX A

Questionnaire

An industrial firm must plan for each of the twelve month for the coming year. The company's production capacities and expected demands (all in units) are provided below.

1.

Months	Demand	Regular Capacity	Overtime Capacity
July			
August			
September			
October			
November			
December			
January			
February			
March			
April			
May			
June			

2. Regular Production cost (in GH¢) for the firm is :

July ………………………..

August ………………………

September …………………………

October …………………………..

November …………………………..

December ………………………….

January ……………………………

February …………………………….

March ………………………………

April ……………………………….

May …………………………….

June ……………………………

3. Overtime Production cost (in GH¢) for the firm is:

July ………………………..

August ………………………

September …………………………

October …………………………..

November …………………………..

December ………………………….

January ……………………………

February …………………………….

March ………………………………

April ……………………………….

May …………………………….

June ……………………………

4. Goods that are not added to inventory are carried forward at a cost of …………….. Per unit.

5. Inventory as at the beginning of the year is ………………………………………………….

6. How is your production scheduling like ?
……………………………………………………………………………………………………

7. How is your inventory control system like?
…………………………………………………………………………………………………..

APENDIX B

Computational Data

The following is the final data used to run the excel model programme to determine the minimum cost production schedule.

Month	Demand	Regular Capacity	Overtime Capacity
July	155000	206000	103000
August	314000	270000	135000
September	143000	234000	117000
October	320000	320000	160000
November	286000	280000	140000
December	181000	220000	110000
January	351000	300000	150000
February	204000	280000	140000
March	306000	322000	161000
April	188000	240000	120000
May	129000	320000	160000
June	213000	322000	161000
Inventory as at July 2008	120000		

APPENDIX C

Result from the Excel Solver

Production Months (Source)	Supply months (Destination)	Shipment	Unit cost (GH₡)	Cost (GH ₡)
Source 1	Destination 2	206000	14	2884000
Source 2	Destination 3	143000	14	2002000
Source 2	Dummy	127000	0	0
Source 3	Destination 4	234000	14	3276000
Source 4	Destination 5	286000	14	4004000
Source 4	Dummy	34000	0	0
Source 5	Destination 6	181000	14	2534000
Source 5	Dummy	99000	0	0
Source 6	Destination 7	220000	14	3080000
Source 7	Destination 8	204000	14	2856000
Source 7	Dummy	96000	0	0
Source 8	Destination 9	280000	14	3920000
Source 9	Destination 10	188000	14	2632000
Source 9	Dummy	134000	0	0
Source 10	Destination 11	129000	14	1806000
Source 10	Dummy	111000	0	0
Source 11	Destination 12	213000	14	2982000
Source 11	Dummy	107000	0	0
Source 12	Destination 13	35000	14	490000
Source 12	Dummy	287000	0	0
Source 13	Destination 14	120000	0	0
Source 14	Dummy	103000	0	0
Source 15	Destination 16	108000	14.22	1535760
Source 15	Dummy	27000	0	0
Source 16	Dummy	117000	0	0
Source 17	Destination 18	86000	14.22	1222920
Source 17	Dummy	74000	0	0
Source 18	Dummy	140000	0	0
Source 19	Dummy	110000	0	0
Source 20	Destination 21	131000	14.22	1862820
Source 20	Dummy	19000	0	0
Source 21	Dummy	140000	0	0
Source 22	Destination 23	26000	14.22	369720
Source 22	Dummy	135000	0	0
Source 23	Dummy	120000	0	0
Source 24	Dummy	160000	0	0
Source 25	Dummy	161000	0	0
Total		5191000		32021220