APPLYING DECISION MODELS TO PRODUCTIVITY OPTIMIZATION

CASE STUDY: DENNIS BLOCK FACTORY

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE (INDUSTRIAL MATHEMATICS)

BY

ENOCH BAFFOE AMOATENG BSc. (Hons.)

INDEX NO. : 20116185

IN

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

(INSTITUTE OF DISTANCE LEARNING)

KUMASI, GHANA

DECEMBER, 2012

DECLARATION

I hereby declare that this thesis is the original work I did with the help of my supervisor. Except for references to other people's work which have duly acknowledged, this work has not been presented in whole for the ward of any degree elsewhere.

ENOCH BAFFOE AMOATENG .... [signature] .... 05-04-2013 ....

Student Name & ID   Signature   Date

Certified By

Prof. S. K. Amponsah .... [signature] .... 19-04-13 ....

Supervisor Name   Signature   Date

Certified by

K F Darkwah .... [signature] .... 5/6/2013 ....

Head of Dept. Name   Signature   Date

DEDICATION

I dedicate this thesis to my lovely wife, Mildred BaffoeAmoateng and my daughter JovannaBaffoeAmoateng whose love and support have motivated me throughout the period of the study.

I dedicate this thesis to my father, Mr Solomon Kwame Amoateng. His motivation, support and desire for my advancement in my studyis greatly appreciated.

ACKNOWLEDGEMENTS

To God Almighty and my Lord and Saviour Jesus Christ, I express my profound and deepest gratitude to you. Your grace and mercy have enabled me to make this milestone. My reverence to you Father.

To Prof. S. K. Amponsah – my wonderful supervisor. I owe you a special debt of gratitude for your excellent guidance, thorough supervision and positive criticism that has engineered the production of this work. I salute you honourable. I say God richly bless and increase you abundantly.

To the staff of the sample company my deepest appreciation for your time, efforts and inputs for being used as a case study in this study. You have my respect Sirs! God bless you.

ABSTRACT

Manufacturers are constantly planning and controlling the acquisition and allocation of resources to produce activities in order to satisfy the demand of customer over a specified time horizon. These planning and control problems are actually optimization problems, since the objective is to develop a plan that meets demand at a minimum cost and maximize profit. This study was undertaken with the aim of helping the manufacturing companies to minimise cost and maximise profit. The researcher was considering how best limited resources are allocated in order to optimise productivity of the manufacturer, who produces variety of goods with the same resource. The study was to tackle product mix optimisation problems, hence the solution to the problem led to development of an application of decision model to productivity optimisation. The intention of the study is to investigate how decision models are being implemented in the company and develop a decision model that will assist the manufacturer to improve productivity. Our target was to minimized cost of production by properly allocation resource at a moderate cost and end up maximizing profit. The research takes into consideration mathematical method that will help to make decision on the allocation of limited resource, linear programming was then considered appropriate to the decision model to optimise productivity and Excel solver was the application used to solve the linear programming problem. It is obvious from the study that the benefits of applying decision model to productivity optimisation are well known to the manufacturing sector and represent a formidable force to drive the adoption by many companies in Ghana. The general reorganisation of the positive impact of productivity optimisation is to reduce cost of doing business, properly allocation of limited resource, improve productivity, meets customers' demand, speed and accuracy delivery of service.

Contents **Pages**

Chapter Three

Chapter Four

Chapter Five

CHAPTER ONE

1.0 INTRODUCTION

Manufacturers are constantly planning and controlling the acquisition and allocation of resources to produce activities in order to satisfy the demand of customer over a specified time horizon. These planning and control problems are actually optimization problems, since the objective is to develop a plan that meets demand at a minimum cost and maximize profit. The optimization problem will differ due to difference in manufacturing and market context.

This research seeks to help the manufacturers, on how to use decision models to optimize productivity. This is essential in our economy which is experiencing recession in the manufacturing sector. The industrial sector is facing a stiff competition with the foreign manufacturers. Globalization is killing our manufacturing sector because they flood our economy with products of cheaper prices compare to ours, hence some are closing down because they do not have competitive edge over their foreign counterpart.

These problems can be tackled in different ways one of it is to apply decision models in the production process. Allocation of resources is done in such a manner to reduce wastage, if not completely eliminated, so that the cost of production will bereduced.When this happens the goods and services produce will be at a low cost and will enable our manufacturers to compete effective in the international market.Applying good decision models to productivity optimization is a healthy venture that our industries should not underestimate. Decision models frequently attempts to find a best solution (optimal solution) for problems under consideration.

Productivity is not only considering the quantity of products produce, rather how the scarce resources are utilized efficiently or economically.

1.1 BACKGROUND OF THE STUDY

Productivity is an important global issue for managers of modern organizations. Not many companies can survive and compete unless a reasonable level of productivity is maintained over time. Productivity is the yardstick by which managerial efficiency is measured. In addition, national economic and social progress depends on productivity improvement. Therefore managers are supposed to make decisions to improve productivity so that they can be considered as efficient managers. The art of decision making that is modelled scientifically is referred to as decision model. Decision models applied mathematical models to solve real world scenario.

There are about two types of decision model, deterministic and probabilistic models.

Deterministic models are the type of decision model where all inputs data values are known with complete certainty.

Probabilistic models have their input data value uncertain.

The type of decision models that this study seems to undertake is the deterministic model, since data will be gathered from the industry.

Productivity means to achieve complete target with maximum output and minimum loss without affecting quality. Let us define it as the output-input ratio within a time period with due consideration for quality.

Productivity = Outputs / Inputs

For productivity optimization, any given input should yield a higher output, hence increase in production. Productivity is considering the contribution of each unit of input to an increase in output. Productivity is treated as a complex multi-dimensional field. Production operations management, management science, quantitative analysis, economics, statistics, and the behavioural sciences are discussed with reference to productivity measurement, analysis, and improvement in a variety of organizational settings. The emphasis is on practical, easy-to-measure approaches that have proved effective in various business and government contexts. These approaches are designed to help readers select the best way to measure, analyse, and improve productivity for their own organizations.

Productivity is a measure of the following:

(i) system performance
(ii) system efficiency
(iii) resource utilization
(iv) the relationship between real output and inputs.
(v) productivity is measured as:the ratio of output to input.
(vi) the ratio between the amount produced and the amount of any resources used in the production.
(vii) output per unit of input (resources)

The Production and Operations Management (POM) is about the transformation of production and operational inputs into "outputs" that, when distributed, meet the needs of customers.

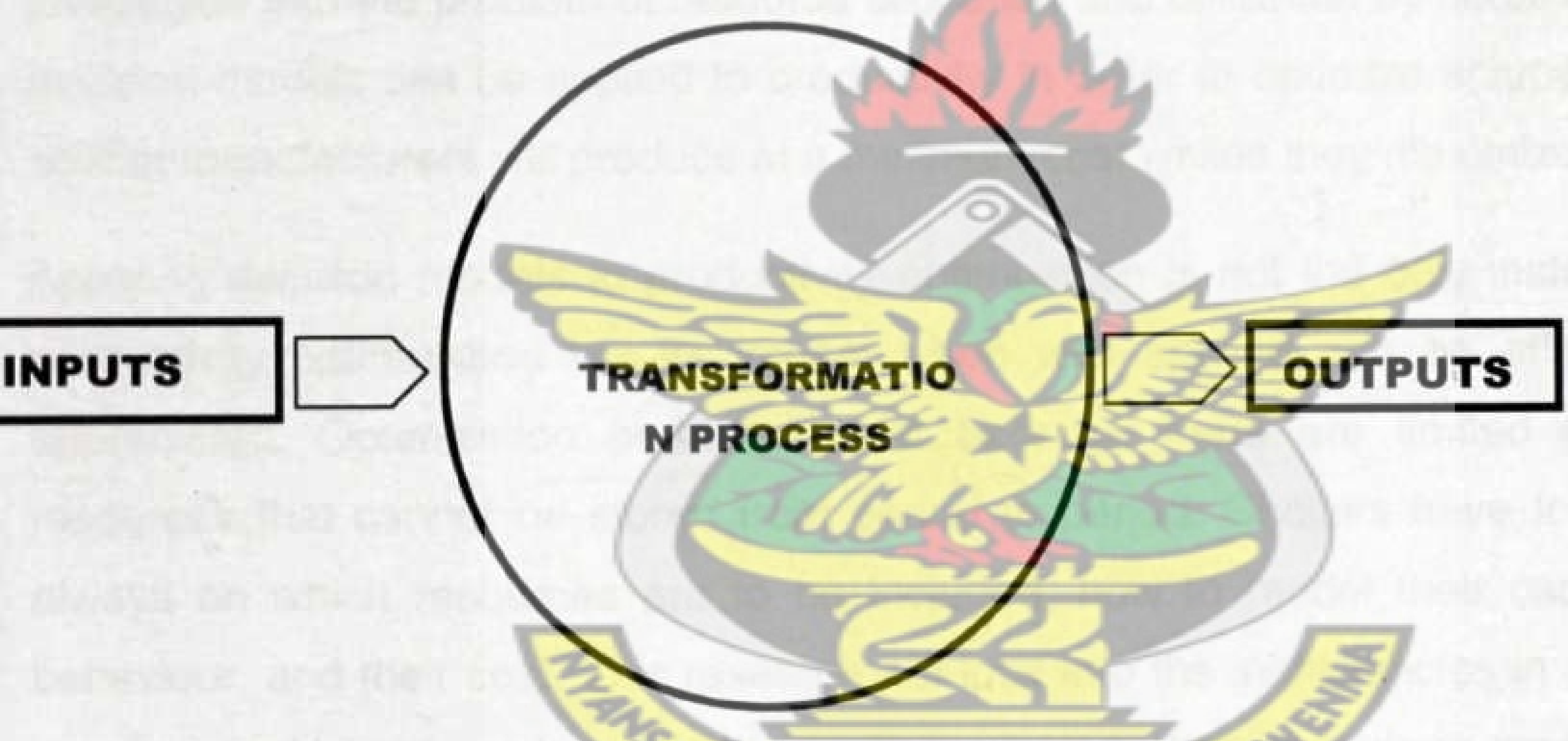


Figure 1.1

The process in Figure1.1 is often referred to as the "Conversion Process". There are several different methods of handling the conversion or production process - Job, Batch, Flow and Group.

1.2 PROBLEM STATEMENT

A good look at our manufacturing sector indicates that it is lacking proper decision models features. Most of the resources for production can be located locally, yet prices of goods and services are high. Example cocoa products are expensive, yet we are among the leading exporters of cocoa, this demonstrates that proper decision models are not applied to productivity in the developing world. Most of decision make in the industries are not science base, and has resulted in wasting most of the resources. Therefore the outcome of planning and controls of our manufacturing sector many a times fail because it has not been built on any scientific basis. In the advance world research are mostly undertake on how best to utilise the scarce resource to maximized profit. The issue to be addressed is, why our manufacturers still not able to produce at a lower or minimized cost. This research seeks to investigate into the problem of resource allocation and utilization by considering how decision models can be applied to productivity in order to optimize scarce resource so that manufacturers will produce at a minimum cost whiles they maximize profit.

Applying decision models to productivity optimization is not the only instrument for productivity optimization but its impact when well applied can be effective and appreciated. Optimization problems exist because there are limited production resources that cannot be stored from period to period. Choices have to be made always on which resources are to be included, how to model their capacity and behaviour, and their cost. This research will look into the inefficiencies in production process, and how it can be addressed with the introduction of decision models.

1.3 OBJECTIVES OF STUDY

Theobjectives of the study are:

(i) to investigate how decisions are made concerning productivity

(ii) to study all the processes involved in the production of key product

(iii) to formulate decision models that will help to improve productivity

(iv) to minimize cost of production and maximize profit

(v) to find bottle necks in the process by analysing the above studies

1.4 JUSTIFICATION OF THE STUDY

This study will help the manufacturing sector of the economy to increase its contribution to the GDP (Gross Domestic Product). For the past decay, contribution of the manufacturing sector is not improving. The cost of production is away high which is killing some of the local manufacturing companies. The study tend to help the local manufacturers to have a good look into how resources can be properly allocated so as to reduce the cost of production and also the meet the demand of customer. The benefits that will be derived are as follows;

(i) proper allocation and utilization of scarce resources
(ii) minimize cost of production, improve productivity and maximize profit
(iii) it will help the manufacturing sector to gain competitive edge
(iv) eliminate wastages in production
(v) streamline production process and speed up production
(vi) produce goods and services demanded by customer in most efficient and economical way

Nevertheless, since the research applies mathematical models to solving productivity difficulties it eliminate ambiguity and gives production manager the best way of handling product mix in order to minimize cost and maximize profit.

1.5 METHODOLOGY OF THE STUDY

The steps below were what the researcher followed to accomplish the study on applying decision model to productivity optimisation.

- Primary data will be used base on interview
- Define problems and gather relevant data
- Formulate a mathematical model to solve the problem
- Test the model
- Implement the decision model designed

1.6 SCOPE OF THE STUDY

The scope of study is extentin which the research will cover. It is very important that the scope is defined so as to help anyone who wants to implement or challenge the research will consider the area which it covers.

The research is basically concentrating on how to apply decision models in productivity optimisation and is limited to Denis Block Factory. It is limited to Ghana since much is not done in this area of our economy, as there is little literature on this subject in relation to the Ghanaian situation. This is to enable the researcher undertake an in-depth study on the problem.

The study covers and examines how applying decision model in a company will can help to optimise productivity. It expanded to existing production model and the extent it has help the company to optimize their production.

1.7 LIMITATIONS OF THE STUDY

In this study we shall focus on optimization models for production of discrete-parts, batch manufacturing environments. We do not cover detailed scheduling or sequencingmodels (e. g., Graves, 1981), nor do we address production planning for continuousprocesses (e. g., Shapiro, 1993). We consider only discrete-time models, and do notinclude continuous-time models such as developed by Hackman and Leachman (1989).

Our intent is to provide an overview of applicable optimization models; we present themost generic formulations and briefly describe how these models are solved. There is anenormous range of problem contexts and model formulations, as well as solutionmethods. We make no effort to be exhaustive in the treatment herein. Rather, we havemade choices of what to include based on personal judgment and preferences.

We were time constrained, as a worker and researcher our available time allocated to the research did not allow us to dive in other areas of interest that we would have prefer to research into.

Accuracy of data was a challenge since some of them were difficult for the manufacturer to quantify.Examples the cost incurs when an experience labour is fired or terminates his appoint, how do you quantify the cost of knowledge that has left the organisation? Future demands are forecasted and makes implementation of the model difficult since the forecast demand are most of the time inaccurate. These are some of the limitations that research has to overcome in order to make the research relevant to the target group.

1.8 ORGANISATION OF THE STUDY

Chapter 1 gives an introduction to the study, it briefly explain the idea behind the research,the problem statement and the need for the research. It identify the objective, justification, limitation, methodology used, scope of the study.

Chapter 2 presents of relevant literature on Productivity Optimization. Specifically, it provides information about the principles of applying decision model to productivity optimisation. It includes the past research conducted on how applying decision model can be used to improve productivity. Furthermore, it explains the significance of effective capacity management in the success of a company in today's competitivebusiness environment and describes the different frameworks used to define production.Chapter 2 also covers the past research, books, articles, journals and information from internetbeing performed on productivity optimisation that applied theprinciples of decision models.

In chapter 3 we shall put forward the research methodology for proposed model that can be used to support the decisionsregarding the product mix of a company. Specifically, this chapter explains how themodel is developed based on the current literature and how the model can be expanded toinclude several alternatives.

Chapter 4 presents data collection and analysis.

Chapter 5 includes the conclusions derived from this research and the contributionof this research to the existing body of knowledge. It also presents a summary of thestudy and identifies future research opportunities.

1.9 SUMMARY

In chapter one, we set out the outline of our study, stating the purpose, specific objectives, scope of study and problem statements. In the next chapter, we shall put forward pertinent literature on Applying Decision Model to Productivity Optimization.

CHAPTER TWO

2.0 LITERATURE REVIEW

In this chapter we present existing literature relevant to the study.

2.1 DECISION MAKING

The essence of management is making decisions. Managers are constantly required to evaluate alternatives and make decisions regarding a wide range of matters. Just as there are different managerial styles, there are different decision-making styles. Decision making involves uncertainty and risk, and decision makers have varying degrees of risk aversion. Decision making also involves qualitative and quantitative analyses and some decision makers prefer one form of analysis over the other. Decision making can be affected not only by rational judgment, but also by non-rational factors such as the personality of the decision maker, peer pressure, the organizational situation, and others(http://www.referenceforbusiness.com/management)

Drucker (2004), as quoted in Association Management, identified eight "critically important"decision-making practices that successful executives follow, each:

(i) Ask "What needs to be done?"
(ii) Ask "What is right for the enterprise?"
(iii) Develop action plans
(iv) Take responsibility for decisions
(v) Take responsibility for communicating
(vi) Focus on opportunities rather than problems
(vii) Run productive meetings
(viii) Think and say "we" rather than "I"

2.1.1 Posing the Problem Correctly

According to Keeney (1998), a Practical Guide to Making Better Decisions, managers commonly consider too few alternatives when making difficult decisions. When approaching a problem, decision makers need to regularly consider starting at the outset, "Is this, what I really need to decide?" In addition, the nature of the problem may change during the decision-making process, as either the situation changes or the decision maker's insights into the situation change.

By not formulating the problem correctly, decision makers risk missing a whole range of other alternatives. Decision makers can improve the chances of asking the right question by probing objectives, goals, interests, fears, and aspirations. They also need to consider very carefully the consequences of each alternative. They can devise new alternatives through brainstorming and imagining as many options as possible, keeping in mind objectives, but not necessarily being entirely practical at first. In practice, action-oriented decision makers tend to focus on solutions without considering whether they are working on the right problem. Instead of choosing from decisions selected by others, decision makers need to review what decisions they should be addressing(www.enotes.com/decision-making-reference).

Managers in a corporate setting tend to view decision making differently than entrepreneurs. Since they are typically given a fixed amount of budgeted resources to work with, managers tend to define a problem in terms of what can be done with the resources at hand. Entrepreneurs, on the other hand, will likely pose the problem in terms of an objective—"This is what I want to get done"—and then worry about finding the resources to accomplish that objective. As a result, entrepreneurial decision makers will lay out a wider range of alternatives from which to choose. They feel less constrained by a lack of resources. To develop more alternatives, decision makers should release themselves from existing constraints, think imaginatively, and brainstorm with others, all the while keeping objectives clearly in mind and being honest about what they really need or desire (www.enotes.com/decision-making-reference/decision).

2.1.2 Uncertainty and Risk

Many decisions must be made in the absence of complete information. Decision makers often have to act without knowing for certain all of the consequences of their decisions. Uncertainty simply increases the number of possible outcomes, and the consequences of these outcomes should be considered. That is, it is important for the decision maker to identify what the uncertainties are, what the possible outcomes are, and what the consequences would be. Decision makers can sometimes clarify the problem they are working on by listing what could happen and assigning probabilities to each possible outcome (a formal representation of this is known as a decision tree) (http://www.referenceforbusiness.com/management).

Risk aversion is another non-rational factor affecting sound decision making. Studies have shown that people who exhibit risk-averse behaviour in one setting will become risk-seekers when offered the same choice in a different setting. For example, most people will display risk-averse behaviour by rejecting a fair gamble in favour of a certain gain. However, when a choice is involves a fair gamble and a certain loss.Most people display risk-seeking behaviour by choosing the gamble over the certain loss, even though the risky choice may wellresult in an even greater loss (Encyclopedia of Management, ©2006 Gale Cengage. All Rights Reserve).

The valuation of a risky alternative appears to depend more on the reference point from which a possible gain or loss will occur, than on the absolute gain to be realized. That is, the decision maker is motivated not by the absolute performance of a particular alternative, but whether that alternative will perform better or worse relative to a specific reference point. Consequently, decision makers can be easily influenced by shifting reference points (Encyclopedia of Management, ©2006 Gale Cengage. All Rights Reserve).

2.1.3 The Role of Information: Decision Support Systems

Armed with information, managers can make better decisions. Frontline managers, for example, who are supplied with direct activity cost information, can better manage revenues, margins, and costs. Organizations can achieve more consistency between upper management and lower-level managers by providing more information throughout the organization.

With Internet-hosted databases and user-friendly query tools becoming more common, corporations are turning to Decision Support Systems (DSS) software to analyse the firm's databases and turn them into information useful for decision makers. DSS typically includes analytical and report-writing features, thus enabling users to translate raw data into a form useful for decision support (www.expertchoice.com).

Decision support technology is a relatively new development in software and may not yet be a high priority with the firm's information technology (IT) department. DSS, which offers users more flexible programming paradigms, can be compared to another type of software, enterprise resource planning (ERP), which enhances productivity by accelerating routine operations. DSS, on the other hand, slices and dices data that may be novel and complex into understandable chunks to facilitate shared consideration of multiple criteria (www.expertchoice.com).

One DSS technique is called analytic hierarchy process (AHP), which enables users to attack complex problems by reducing them to simpler pair wise comparisons between different combinations of options and criteria. When people are able to choose between pairs of options, their decisions are made more quickly and consistently than when larger sets of options must be considered. AHP was invented by Thomas Saaty (2008), who cofounded Expert Choice Inc. to provide AHP-related software and services.

DSS can speed collaboration when there are several decision makers who must be satisfied. By providing multiple users with access to the firm's data, DSS can clarify the decision-making process and enhance consistency among multiple decision makers. With electronic commerce competitors responding to strategic decisions within days or even hours, the speed with which decisions are made becomes more critical. DSS helps decision makers consider a wider range of alternatives in a shorter period of time. When more consideration is given to the probability and value of the competition's response, strategic decision making becomes more like game theory by Eienhardt (1999).

2.1.4 Strategic Decision Making

Strategic decisions are those that affect the direction of the firm. These major decisions concern areas such as new products and markets, acquisitions and mergers, subsidiaries and affiliates, joint ventures and strategic alliances, and other matters. Strategic decision making is usually conducted by the firm's top management, led by the CEO or president of the company

(www.enotes.com/decision-making-reference).

In markets characterized by extreme competition and a rapid pace of change, companies are being forced to compete on the edge. Their strategic thinking can no longer be limited to identifying promising industries, core competencies, and strategic positions. Rather, top management is engaged in creating a continuing flow of temporary and shifting competitive advantages relative to other competitors and the market being served. As a result, greater emphasis is placed on efficient strategic decision making to create effective strategies.

Eisenhardt (1999) studied the strategic decision-making processes at different companies in high-velocity markets. Strategic decision makers at more effective firms were able to make quick, high-quality decisions that were widely supported through-out the firm. Her studies identified four areas in which effective strategic decision makers outperformed counterparts at less effective firms: (1) building collective intuition, (2) stimulating conflict, (3) maintaining a pace or schedule for decision making, and (4) defusing political behaviour.

2.1.5 Predictive Markets

Also termed "betting markets" or "idea markets," prediction markets emerged during 2004 as a way to assess consensus opinion about questions of importance to corporate decision makers. As discussed by Pethokoukis (2004) in U.S. News and World Report, companies such as Hewlett-Packard and Dentsu were exploring use of prediction markets to forecast corporate figures such as revenues, advertising demand, consumer trends, and employee retention. These markets enable companies to determine what products or decisions are more likely to be successful and where to focus resources. Firms were still researching how well this works and where it could best be applied. A senior manager at Dentsu explained, "The key value we see is that prediction markets have the potential to extract the best essence from group knowledge, as an alternative to majority decisions."

2.1.6 Maintaining a Schedule

Strategic decision makers are faced with a dilemma when they feel that every strategic decision they make is unique, yet they feel pressured to make decisions as quickly as possible. Effective decision makers overcome this dilemma by focusing on the pace of decision making, not the speed with which a decision is made. By using general rules of thumb regarding how long a particular type of decision should take, they maintain decision-making momentum by launching the decision-making process promptly, keeping up the energy surrounding the process, and cutting off debate at the appropriate time (www.enotes.com/decision-making-reference).

In order to keep to a specific time frame, executives can alter or adjust the scope of a particular decision to fit the allotted timeframe by viewing it as part of a larger web of strategic choices. Eisenhardt (1999), studies found that effective decision makers followed the natural rhythm of strategic choice. The rule for how long major decisions should take was a fairly constant two to four months. Decisions that would take less time were considered not important enough for the executive team, while those that appeared to take longer involved either too big an issue or management procrastination. By recognizing similarities among strategic decisions, such as those involving new products, new technologies, or acquisitions, executives could more easily gauge the scale of decision.

One of the most effective methods for cutting off debate was a two-step method called "consensus with qualification." The decision-making process is conducted with consensus as a goal. If consensus is achieved, then the decision is made. However, if there is no consensus, then the deadlock can be broken by using a decision rule such as voting or, more commonly, letting the executive with the largest stake in the outcome make the final decision. By taking a realistic view of conflict as both valuable and inevitable, consensus with qualification helps maintain the pace of decision making. It helps managers plan progress and emphasizes that keeping to schedule is more important than forging consensus or developing massive data analyses (Encyclopedia of Management, ©2006 Gale Cengage. All Rights Reserve)

2.1.7 An Eight-Step Approach to Making Better Decisions

The following list is adapted from Smart Choices by Hammond et al,. (1998): Work on the right decision problem. Be careful in stating the problem, and avoid unwarranted assumptions and option-limiting prejudices.

Specify your objectives, determine what you want to accomplish, and which of your interests, values, concerns, fears, and aspirations are the most relevant.

Create imaginative alternatives, alternatives represent different courses of action, and your decision can be no better than your best alternative.

Understand that the consequences determine how well different alternatives satisfy all of your objectives.

Grapple with your trade-offs,since objectives frequently conflict with each other, it becomes necessary to choose among less-than-perfect possibilities.

Clarify your uncertainties, confront the uncertainty by judging the likelihood of different outcomes and assessing their possible impacts.

Think hard about your risk tolerance, in order to choose an alternative with an acceptable level of risk, become conscious of how much risk you can tolerate.

Consider linked decisions, many important decisions are linked over time. The key to making a series of decisions is to isolate and resolve near-term issues while gathering information relevant to issues that will arise later.

2.2 OPTIMIZATION MODEL

In mathematics, computer science and economics, optimization or mathematical programming refers to choosing the best element from some set of available alternatives, (en.wikipedia.org/wiki/Optimization_(mathematics)).

Optimization is therefore defined as a process of finding the "best" solution or design to a problem. Optimization is considered to be everywhere;

It is embedded in language, and part of the way we think.

Firms want to maximize value to shareholders

People want to make the best choices

We want the highest quality at the lowest price

When playing games, we want the best strategy

When we have too much to do, we want to optimize the use of our time

Optimization model is applying mathematical model to find the best or optimal solution to a real world scenario. Decision making always poses alternates, and with these alternates one of them will give the best solution to a problem. By using some mathematical models example linear programming, one can come out with the optimal solution.

To achieve the optimal solution, the following has to be considered:

(i) What do we mean by the "best"?Cost, performance, aesthetics, social or individual "well-being", etc.The objective implied by "best" will vary with the problem and designer/client.

(ii) Why can't all intensive? Because of constrain. Can't make everybody perfectly happy, but have to do the "best" within constraints.

(iii)Optimization selects the "best" decision from a constrained situation.Obviously; the "best" solution is driven by your objectives for solving a problem.

Many companies are now using optimization andlinear programming extensively to decide how to allocate resources.The increase in the speed of computers has enabled the solution of far larger problems, taking some of the guesswork out of the allocation of resources. For a while these companies are optimizing the allocation of resources, it helps them to minimized cost of production whiles maximizing the profit margin.

Some Thoughts on Optimization

"All models are wrong, but some are useful." - Box (1979), Robustness in Statistics.

"Operations research is the art of giving bad answers to problems to which otherwise worse answers are given." - Saaty (1959), Mathematical Methods of Operations Research.

"What would life be without arithmetic, but a scene of horrors" – Smith (1835)

"Decision analysis separates a large-scale problem into its sub-parts, each of which is simpler tomanipulate and diagnose. After the separate elements are carefully examined, the results are synthesizedto give insights into the original problem." - Wagner (1975), Principles of Operations Research.

"The adoption of operations research calls for an act of faith in the potential benefits of a systematicapproach to decision-making." -Wagner (1975), Principles of Operations Research.

"Even when quantitative analysis is of central importance for a managerial decision process, anoperations-research-oriented system never supplies all the information required for action, no matter howsophisticated the system's design. Furthermore, a truly successful implementation of an operationsresearch system must apply behavioural as well as mathematical science, because the resultant systemmust interact with human beings. And finally, the very process of constructing an operations researchsystem involves the exercise of judgement in addition to the logical manipulation of symbols and data." - Wagner (1975), Principles of Operations Research.

"Le mieuxestl'ennemi du bien."The best is the enemy of the good. - Voltaire

"A man's gotta know his limitations." - Eastwood

"A problem well put is a problem half solved." - Anon.

"The bottom line for mathematicians is that the architecture has to be right. In all the mathematics that Idid, the essential point was to find the right architecture. It's like building a bridge. Once the main linesof the structure are right, then the details miraculously fit. The problem is the overall design." FreemanDyson, "Dyson: Mathematician, Physicist, and Writer" interview with Albers (1994), "An expert problem solver must be endowed with two incompatible qualities, a restless imagination and a patient pertinacity." Eves in Mathematical Circles, Boston: Prindle, Weber and Schmidt (1969).

"The errors of definitions multiply themselves according as the reckoning proceeds; and lead men intoabsurdities, which at last they see but cannot avoid, without reckoning anew from the beginning."Hobbes, in Newman (ed.) the World of Mathematics, New York: Simon and Schuster (1956).

"In order to translate a sentence from English into French two things are necessary. First, we mustunderstand thoroughly the English sentence. Second, we must be familiar with the forms of expressionpeculiar to the French language. The situation is very similar when we attempt to express inmathematical symbols a condition proposed in words. First, we must understand thoroughly thecondition. Second, we must be familiar with the forms of mathematical expression.Polyá, How to Solve It. Princeton: Princeton University Press. 1945.

2.3 PRODUCTIVITY

Productivity is an important global issue for managers of modern organizations. Not many companies can survive and compete unless a reasonable level of productivity is maintained over time. Productivity is the yardstick by which managerial efficiency is measured. In addition, national economic and social progress depends on productivity improvement.

Productivity Management-A Practical Handbook treats productivity as an important corporate asset that must be promoted by everyone in the organization. Productivity concepts, measurements, improvements, analysis, techniques and policy are themes included in the book.

Prokopenko (1987) tied an impressive amount of material on productivity issues in both developing and industrialized countries. The book thus constitutes a valuable contribution to the literature and provides excellent guidelines for managers, management consultants, training personnel, trade unions, productivity specialists, and graduate students. Productivity is treated as a complex multi-dimensional field.

Sardhara and Kapadia, (2008) expressed their opinion on productivity; Successful companies create a surplus through productive operations. Although there is no complete agreement on the true meaning of productivity, yet productivity means to achieve complete target with maximum output and minimum loss without affecting quality. Let us define it as the output-input ratio within a time period with due consideration for quality.

Productivity = Outputs / Inputs.

A company business depends on productivity, services. Cutajar(2010), made this observation, the production function within an organization is dependent upon other areas of the organization to forecast future demands and levels of production.

The production process involves the planning and control of how goods will be manufactured. This usually includes the identification of raw materials required, the quantities of components needed to manufacture items, and the human workforce required to produce these products. These functions are the tasks carried out by the Production Planning and Control Department.

Steve (2005) in his article 'what is productivity' defined productivity to be equal to value divided by time.

Productivity = Value / Time

By this definition there are two primary ways of increasing productivity

(i) Increase the value created

(ii) Decrease the time required to create that value

In the article the value in the equation were considered to be made up of; impact, endurance, essence and volume hence the formula for value is as below

Value = Impact x Endurance x Essence x Volume

And therefore

Productivity = Impact x Endurance x Essence x Volume / Time

Steve (2005) further commented that, 'what was interesting here is that most of the productivity literature I have read focuses almost exclusively on volume and time. But those are the most limiting parts of this equation. However, they're also the easiest to write about. I think the most important long-term factors to consider when optimizing productivity (whether that of an individual, corporation, country, or other entity) are impact, endurance, and essence. And the most important of these three is essence.'The pursuit of essence is essential if you wish to have a nonzero productivity. Source is from (http://www.stevepavlina.com/blog/2005/10/what-is-productivity/)

2.3.1 Production Planning Process

The production planning process within the production department involves the planning of what materials are required for the production of supplies and what is required to put these materials together. Issues to consider when conducting the production planning process include:

Future DemandPlanning – what is the trend of customers' orders? Are there any upcoming events that might increase or decrease the number of orders?

Lead Times – What are the time frames to manufacture an item? Are all the materials and tools required to manufacture an item available?

Components Availability – are the components required to manufacture an item in stock? If the components are to be ordered this has to be taken into account and included in the time required to manufacture the item.

Workforce Availability – this takes into consideration the skills and availability of the workforces and the source for this information is

(http://www.stevepavlina.com/blog/2005/10/what-is-productivity)

The above considerations will be taken into account by the production team during the planning activity as a reference to organize the work involved according to the skills and machinery available.By drawing up thorough production planning procedures that take into account all the materials and time required to manufacture a product, it is possible to calculate the production planning tools required and the cost of manufacturing.

2.3.2 Production Control Process

Production quality control involves the monitoring of the product manufacturing to ascertain that the products are produced according to the methodology specified and that the product performs to the planned functionality.

These functions are performed by the Quality Control team. Their role is to check products to ensure that they meet the company's manufacturing standards. Quality control inspection will then proceed to identify any flaws in the established process.The ultimate aim of production control is to minimize the number of product rejections and ensure that the process of production is optimized.

2.3.3 Importance of Production Planning and Control

To summarize the planning and control functions within a production department involve three main activities:

Production work is initiated

The work carried out is measured and monitored

Any necessary alterations are made.

These three main activities are referred to as the classic feedback control loop. The feedback control loop may yield results that indicate a necessary change in raw materials, manufactured items and so on.

2.4 APPLYING DECISION MODEL TO PRODUCTIVITY OPTIMIZATION

This study on productivity optimization has been undertaken by a lot of researchers, applying different methods to optimized productivity which we are going to review.

Graves (1999) considered manufacturing planning and control address decisions on the acquisition, utilization and allocation of production resources to satisfy customer requirements in the most efficient and effective way. Typical decisions include work force level, production lot sizes, assignment of overtime and sequencing of production runs. Optimization models are widely applicable for providing decision support in this context.

In many planning contexts, an important construct is to set a planning hierarchy.Namely, one structures the planning process in a hierarchical way by ordering thedecisions according to their relative importance. Hax and Meal (1975) introduced thenotion of hierarchical production planning and provide a specific framework for this, whereby there is an optimization model with each level of the hierarchy. Eachoptimization model imposes a constraint on the model at the next level of the hierarchy. Bitran and Tirupati (1993) provide a comprehensive survey of hierarchical planningmethods and models

Roy, Falomir and Lasdon (1982) wrote a paper on, a unique modeling and optimization system has been used that has resulted in more active participation of management in the modeling process. The paper focuses on the benefits of using optimization as well as the role of the optimization system.

Vasant, and Barsoum (2007), in Fuzzy optimization of cost function in product mix selection problem, of World Congress, Volume # 16 | Part# 1 stated "The modern trend in industrial application problem deserves modeling of all relevant vague or fuzzy information involved in a real decision making problem. In this paper the usefulness of the proposed S-curve membership function is established using a real life industrial production planning of a chocolate manufacturing unit. The unit produces 8 products using 8 raw materials; mixed in various proportions by 9 different processes under 29 constraints. A solution to this problem establishes the usefulness of the suggested membership function for decision making in industrial production planning. The objective of this paper is to find the optimal cost to produce 8 products using modified S-curve membership function as a methodology. The fuzzy linear programming approach is used to solve this problem. The optimal cost function is obtained respect to two major factors of degree of satisfaction and vagueness."

Chou and Hong (2000)proposed a methodology for product expressed that since a semiconductor foundry plant manufactures awide range of memory and logic products using the make-to-order business model, the product mix is an important production decision. This paper first describes the characteristics of the product mix planning problem in foundry manufacturing that are attributable to the long flow time and queuing network behaviours. The issues of time bucket selection, mix optimization and bottleneck-based planning are next addressed.

Wen et al,. (2011), in the Use of Approximate Dynamic Programming for Production Optimization is summarized as in production optimization, we seek to determine the well settings (bottomhole pressures, flow rates) that maximize an objective function such as net present value. In this paper we introduce and apply a new approximate dynamic programming (ADP) algorithm for this optimization problem. ADP aims to approximate the global optimum using limited computational resources via a systematic set of procedures that approximate exact dynamic programming algorithms. The method is able to satisfy general constraints such as maximum watercut and maximum liquid production rate in addition to bound constraints. ADP has been used in many application areas, but it does not appear to have been implemented previously for production optimization. The ADP algorithm is applied to two dimensional problems involving primary production and water injection. We demonstrate that the algorithm is able to provide clear improvement in the objective function compared to baseline strategies. It is also observed that, in cases where the global optimum is known (or surmised), ADP provides a result within 1-2% of the global optimum. Thus the ADP procedure may be appropriate for practical production optimization problems.

Sinhal, Al-Kandarl, and Al-Anezil (2006) article made it known that Production optimization ensures that wells and facilities are operating at their peak performance at all times to maximize production. Frequent changes in well and surface equipment down time, maintenance work, evolving reservoir conditions etc. usually make it impossible for the team to keep the asset tuned for optimal operating conditions. The current manual production optimization approaches are both time consuming and error pronedue to the complexity and large volume of data that have to be considered. In the present work, several tasks and processes have been streamlined and automated with effective linkages to achieve a near real time optimization. The measure–calculate-control cycle is implemented every twenty-four hours, a procedure which maintains the system at optimal operating conditions almost all the time. Used on a daily basis to manage mature assets and make operational decisions, the system integrates production data management and reservoir rmodeling with transient pressure analysis, well modeling, and surface network modeling optimization. A sequential non-linear programming solver is used to optimize hundreds of critical parameters. A multi-disciplinary team approach has been used to implement the process of production optimization using Internet, computer network, communication links, timely team meetings and corporate database. The focus has been on reducing the cycle time for conversion of data to information, decisions, and actions by developing an appropriate system. The benefits of optimization are significant. Gains include a moderate improvement in uptime, along with a significant improvement in produced volume and overall reduction of lifting and operating costs.

Real Time Production Optimization of Offshore Oil and Gas Production Systems: A Technology Survey, a paper prepared by Bieker et al., (2006). The elements in this description include data acquisition, data storage, processing facility model updating, well model updating, reservoir model updating, production planning, reservoir planning, and strategic planning. Methods for well allocation, gas lift and gas/water injection optimization and updating of the modelsare reviewed in relationship with the information flow described. Challenges of real time optimization are discussed.A business converts economic resources into something else. It may do so well or poorly. At this level, productivity is the balance between all production factors that will give the greatest return for the least effort (Drucker, 1974). Productivity at the organizational level is considered separately from productivity at lower levels.

The customer buys utility (Jury, 1992), and productivity associates outputs with inputs. Productivity, at the organization level, may be considered a measure of how well the company satisfies the customers' utility. Therefore, productivity measurement shows how well a company is doing. This does not, however, tell anything about why the company is performing the way it is. To discover why, productivity must first be examined at lower levels such as the work group, which are best suited for using productivity measures as an indication of change (Rittenhouse, 92).

The concept of productivity is often vaguely defined and poorly understood, although it is a widely discussed topic. Different meanings, definitions, interpretations and concepts have emerged as experts working in various areas of operations have looked at it from their own perspectives (Sardana, 1987). But a different view is that the terms `performance' and `productivity' are used incorrectly. People who claim to be discussing productivity are actually looking at the more general issue of performance. Productivity is a fairly specific concept while performance includes many more attributes. Knowledge work is the area that offers the greatest opportunities to increase productivity (Drucker 1974). In the past, the production line received a lot of attention because it was relatively easy to analyze and measure. On the other hand, management does not clearly understand what goes on in white-collar work areas, or how to match white-collar personnel needs to future business needs (Strassman, 1985andShackney, 1989).

The production environment has been measured heavily and continues to dominate productivity efforts in spite of evidence that the returns on further refinements do not equal those possible in the white-collar environment.

In a paper presented to the Centre for Economic Policy Research at Stanford University (Lau 1983), commented on productivity as follows: By comparing the sets of production possibilities of an economy at two or more different points in time, we infer whether there has been a change in the productive potential, that is, whether there is any input-output combination that is feasible at the later date but not feasible at the earlier date or vice versa. What is interesting, in a world of scarcity, is whether we can obtain the same output with less resources, or a higher output with the same resources. This is where improvement in productivity or technological progress becomes important. The principal reason for our interest in the measurement of productivity is to identify and quantify technological progress.

Using the simplest theoretical example-one input and one output-if input increases, a corresponding output increase is expected (if inputs are not squandered and the system is rational). Figure 2.1 shows this relationship. When technology changes, so does the relationship between input and output. Figure 2.2 demonstrates this change as it affects the example in Figure 2.1.

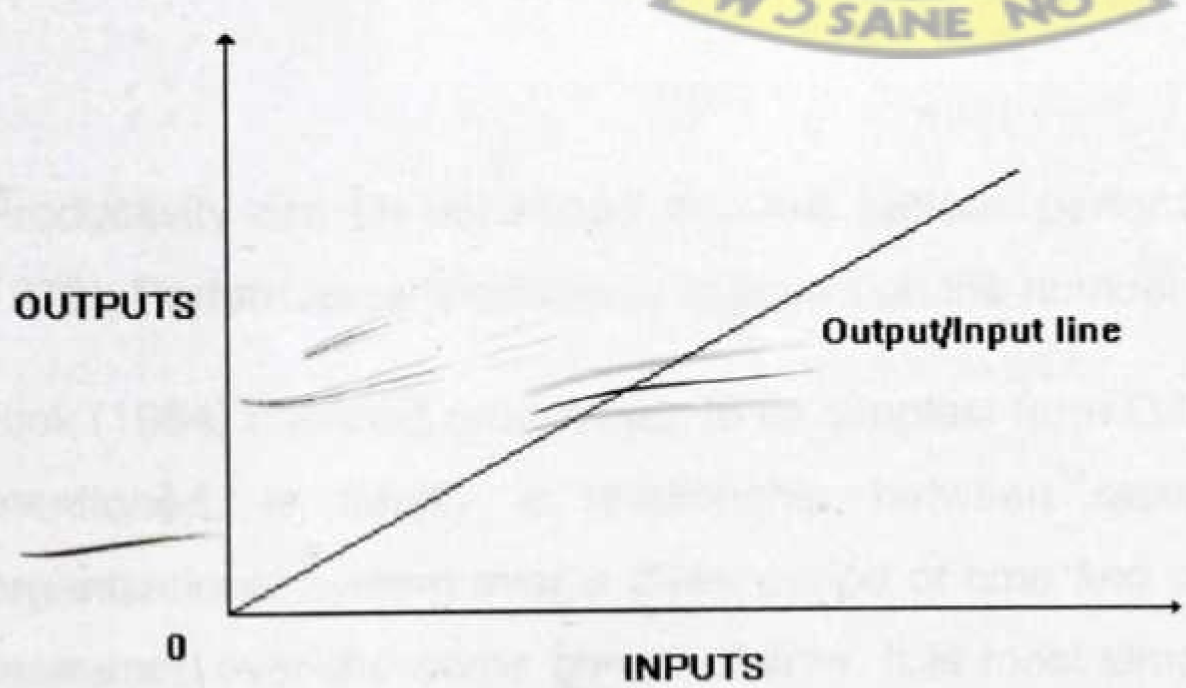


Figure 2.1. One Input and One Output

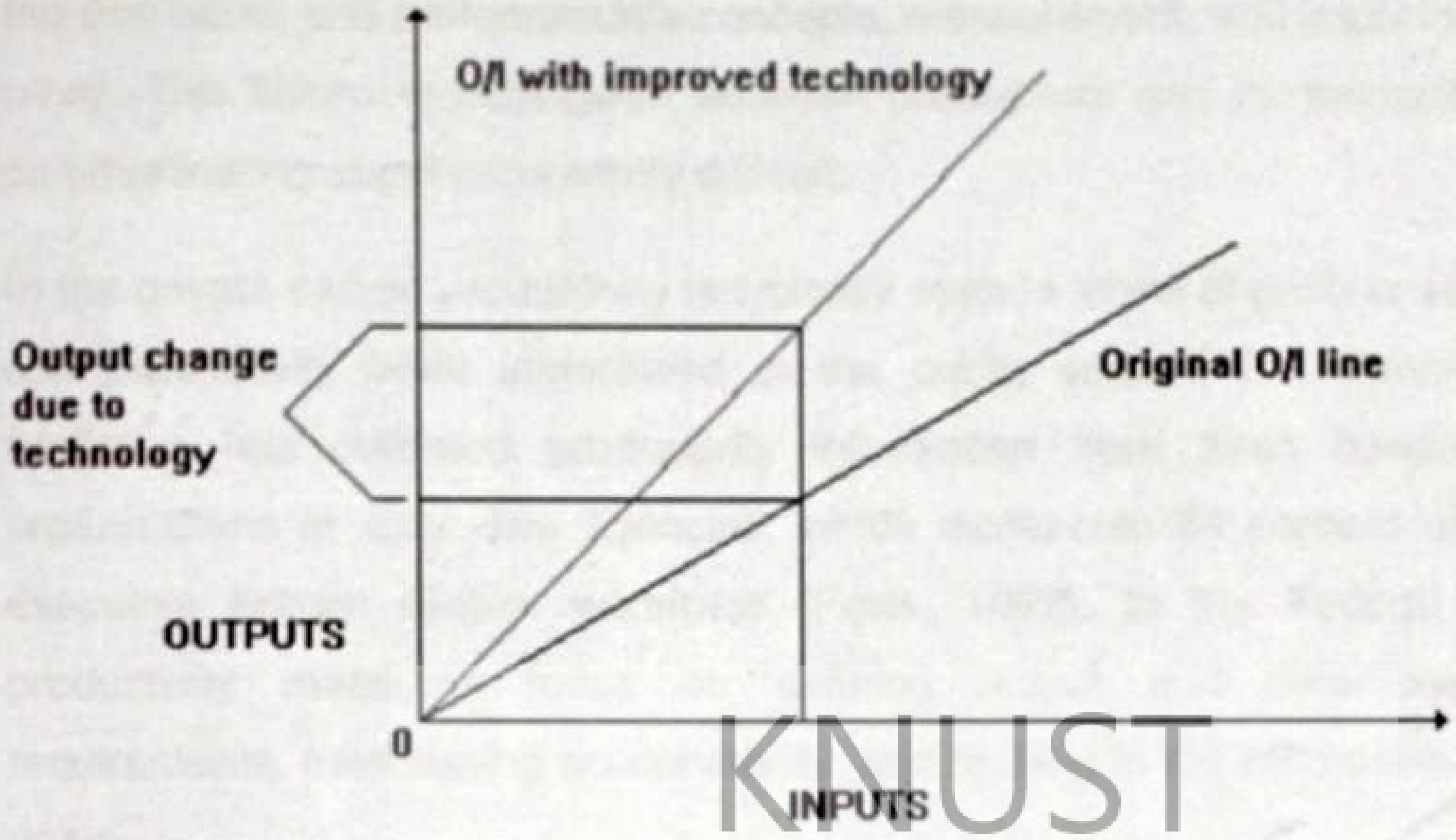


Figure 2.2. O/I with Improved Technology.

The output/input lines shown on these graphs depict the maximum output achievable for a given level of input. Lau (1983) labels this the "production possibility frontier." For any amount of input, this line shows the level of output the economy must produce to be considered efficient.

Sardina and Vrat (1987) say those who measure productivity should have three objectives: (i) to identify potential improvements; (ii) to decide how to reallocate resources; and (iii) to determine how well previously established goals have been met. Sardina and Vrat use a broad definition of productivity that tells the observer how the measured organization is doing as a whole.

Productivity can be separated into two factors: performance and financial (Moore, 1978). Performance productivity is based on the number of outputs produced.

Sink (1984) confined productivity to its simplest form-O/I. He states, "Productivity, as mentioned, is strictly a relationship between resources that come into an organizational system over a given period of time and outputs generated with those resources over the same period of time. It is most simply Output divided by Input." He also states that managers create confusion about productivity because they do not distinguish between productivity's definitions, measurement, and improvement on the one hand, and performance's concepts, measurement, and improvement, on the other. This failure to distinguish between productivity and performance can make communicating about productivity difficult.

In the private sector, productivity is typically seen in terms of profit or sales. But how can productivity been understood in the public sector? The Bureau of Labour Statistics has collected productivity information from three hundred and four organizations in sixty -two agencies, which represents 64 percent of the Federal executive branch civilian workforce (Forte, 1992). In the Federal government, productivity measures focus on defining output and determining resource requirements, establishing accountability, and helping in the estimation of production goals.

There is a distinct difference in the productivity of an organization and the productivity of a single work unit of that organization. Sardina and Vrat (1987) indicated this difference by use of their third objective-to establish measures that reflect an organization's degree of success in meeting its established goals. The goals for each level of the organization should differ to represent the contribution that specific level expects to make toward overall organizational goals. Therefore, each level's productivity evaluation should be different, reflecting its unique goals.

Economic theory differs when applied at the national level from when applied to an individual business. One is called macroeconomics and the other microeconomics. Productivity may be viewed in a parallel manner, with macro-productivity referring to productivity at the national level, micro-productivity referring to productivity at the business level, and nano-productivity referring to productivity at sub-organizational levels. A general definition of productivity is possible, but to use it one must indicate the intended level of use, i.e., the national economy, firm, plant, department, or the individual (Thor, 1988).

Bridges (1992) gave one fundamental reason for measuring productivity: "Some type of benchmark (standard, average, mean) should be determined, if none exists. How can you be sure of how much is being saved if you do not have a baseline?" Drucker (1974) has put it in a more general way: "Without productivity objectives, a business does not have direction. Without productivity measurement, it does not have control."

Sink (1985) presented several techniques of evaluating productivity. His three main methodologies are Multi-Factor Productivity Measurement Model (MFPMM), Normative Productivity Measurement Methodology (NPMM), and Multi-Criteria Performance/Productivity Measurement Technique (MCP/PMT). MFPMM is a computerized methodology for measuring productivity, based strictly on O/I. NPMM uses structured group processes to formulate appropriate productivity measures for white-collar or knowledge workers. It uses the group technique to establish consensus about what the productivity measures are and how they should be measured. MCP/PMT is designed to allow the user to evaluate the various productivity measures and decide which are the most important. It also allows the user to aggregate dissimilar productivity measures.

A number of other researchers use the group technique. Bernard (1986) discussed project teams and stresses maximizing their diversity, warning that it cannot be assumed that the manager knows what is going on.

Bridges (1992) states, "The keystone to implementing productivity improvements is putting everything in measurable terms." Frazelle (1992) says "productivity must be understood before it is effectively measured." Productivity improvement is tied to productivity measurement, which is tied to the measurement of the work. The beginning step is measuring work.

Production Planning and Control with Discrete Lotsizing and a Rolling Horizon, a Joint work of: Dangelmeier et al.,(2009). They consider a production system with discrete lotsizing as it is given in the automotive industry. At any point of time only orders in the near future are known, but still the production has to be planned - leading to rolling horizons. Decisions that are made today should avoid bottlenecks in stock and capacity that will handicap future production.

2.5 SUMMARY

In this chapter we presented relevant and adequate literature review on the study, Applying Decision Model to Productivity Optimization.

In the next chapter, we shall address the research methodology of the study.

CHAPTER THREE

3.0 METHODOLOGY

The concept of product mix analysis is simple to illustrate and the result is easy to comprehend. It is therefore not surprising that numerous textbooks also use a product mix problem to introduce the concept of optimization and linear programming. The application of product mix optimization results from its simple yet powerful application, providing a platform to base the search for higher profitability and production throughputs. A quantitative method in industry is an effective application of product mix analysis is not nearly as simple as illustrated in books.

We shall therefore outline the necessary methodology, challenges and possible pitfalls of a practical application of product mix analysis to improve the profitability of an operation or business.Product mix analysis is not as simple as it looks. In a typical textbook illustration of a product mix problem, a company produces several products, each requiring a certain amount of labour and materials. Constraints, such as total amount of resources and the maximum number of units that each product can sell, as well as the unit profit for each product, are given.

The research focuses on how many products to produce in order to maximize the overall profit, correctly illustrating the essence of the product mix problem. However, the case does not even begin to reveal the complexities of a real and practical product mix study commonly used in industry.First, the data needed for product mix study does not come in a handy form that is ready to import by the researcher into a spreadsheet for quick analysis. Obtaining and formatting the necessary information for study requires at least a few days and up to several months, depending upon the scope, complexity and purpose of the analysis.After the first hurdle in data requirements is crossed and initial analysis of the product mix is conducted, the researcher is faced with the next issue: Is the current "optimized" product mix truly the best? In practical applications, the product mix study is rarely a one-shot deal, taking time and effort. Analysis is iterative, each iteration representing one of numerous different production scenarios.The third difficulty of product mix analysis is its implementation. Even after an "optimal" product mix is found, the realization of the product mix within the operation is a challenge. An optimized product mix usually represents an idealized and somewhat macro view of the production profile, delivering a profit obtained in the analysis. In many cases, however, operational constraints in production and in the supply chain that were not or cannot be specifically formulated into the product mix optimization such as availability of raw materials, seasonality of customer demand and bottlenecks of equipment and resources may deem your product mix results infeasible. The researcher followed the roadmap to improve the success rate of a product mix study.

Steps of the product mix study:

(i) define the product mix problem.
(ii) sample case
(iii) type of Data
(iv) collect data for base-line product mix evaluation.
(v) develop new scenarios for additional product mix analyses.
(vi) select the optimal product mix profile.

3.1 THE PRODUCT MIX PROBLEM

The purpose of a product mix study for a profit making entity is usually to maximize the profit. Assuming this general principle, one needs first to define and understand the study. The following questions clearly identify the problem or opportunity and provide focus to the research.

What is the objective of this product mix study?

What are the issues involved with this research?

Why is it important?

Who is the sponsor for this research?

Who should be working on this research?

When should the research start? Finish?

What is the current product mix?

What is the current profit picture?

By answering the above questions, one achieve a much better understanding of the issues involved and point the project in the right direction toward a successful analysis.

Selection of Case

The researcher focus is on the manufacturing companies in Accra and Tema metropolis since most of the case is situated in Accra. The researcher sent a questionnaire to the corresponding case on how decisions are made concerning productivity and how efficiently is the decision on allocation of resources. The reason for choosing manufacturing companies in Accra and Tema metropolis emanated from the fact that these areas have companies that are involve in product-mix type of products.

The resources invested in manufacturing companies are huge and therefore they have to make the right decision on how to maximize the allocation of resources. Yet most of the companies in Ghana go through a lot of difficulty in breaking even, other than maximizing profit. The researcher seeks to develop a decision model that will help in allocation of resource to minimize cost and maximize profitability. The researcher is of the view that if determinants are clearly understood and established, then the companies would reap its intended benefit. It was therefore necessary to use the manufacturing companies as case study to examine effect of applying decision models to productivity optimization.

Moreover, the choice of case study was influenced by the easier accessibility of the researcher to have all relevant data and information for his research findings since he is staying in the same region.

Type of Data

Both primary and secondary data will be used in our study. Primary data that will provide empirical data will be collected through, interviews, and administration of structure questionnaires. These will give specific responses to our research questions. Primary data is recognized data that is gathered for a specific research in response to a particular problem through interviews, questionnaires or observations. Secondary data information is that obtained through various kinds of documents, e.g. Research reports, Annual reports, books and articles.

According to Denscombe (2000) interviews are suitable when there is the need to gather detailed data and information from very few respondents, but the researcher would have to decide whether or not the study needs the type of information and if it will be possible to rely on the information these few respondents would provide the researcher with.

3.2 DATA FOR BASE-LINE PRODUCT MIX EVALUATION

The most important decision of this section is to define the product categories to use as the basic unit to collect needed information. A typical company sells hundreds or even thousands of products representing various product lines, product classes, product sub-classes, packing codes, etc. It is extremely cumbersome and difficult to conduct product mix analysis at the lowest product classification level with thousands of categories. Aggregation is always needed. The question is therefore how to aggregate product sub-classes such that the analysis will still yield insightful outputs. Aggregation as much as possible while retaining enough identity for useful interpretation. This is not an exact science, perhaps even requiring some piloting to ensure that the data collection is neither over detailed nor too general. This is a very time-consuming period of the project. In the case of an entity with a good database containing accurate financial and operation information, effort is usually spent on the aggregation of information to arrive at the desired product category level. To alleviate any ambiguity during the data collection and aggregation process, design a spreadsheet, clearly listing product categories and information to be collected first. With a clear list of information needs, the goal of the data collection is simply to complete the spreadsheet that was specifically designed for data collection.Typical information to be collected for product mix analysis will include items such as product price, product costs — fixed or variable overheads — and estimated demand for the product at the planned horizon. The researcher asks of two numbers for the estimated demand: one number for the expected demand and the other for a higher estimated demand if the product is pushed given a price reduction. Processing information for each product such as equipment usage requirements for key equipment and resources must also be collected. Detailed processing information for all equipment is not really necessary. Identify the key constraints in the production process first, and then collect equipment usage requirements for the potentially constrained equipment only.

3.2.1 Sampling

A sampling approach was used in the selection of subjects, out of the many manufacturing companies, those involve in product-mix type of production was the subject of investigation to the study. The approach was to visit the subjects at the site of their companies.

3.2.2 Data Analysis

Data analysis generally consists of examining, tabulation or otherwise recombining the evidence to address the initial proposition of study. According to Yin (1994), the ultimate goal of analyzing data is to treat the evidence fairly, to produce compelling analytical conclusions and rule out alternative interpretations. In another sense data analysis is seen to consist of three concurrent flows of activities (Miles and Huberman, 1994). These are data reduction, data display, and conclusion drawing and verification.

Data reduction as an integral part of data analysis will be carried out to sharpen, sort focus, discard and organized the data in a way that allow for final conclusions to be draw and verified.

Data display refers to an organized information that permits conclusions drawing and action taking. Deductions and conclusion will be draw from the data to decide what things mean from the beginning of data collection. We do this by noting regularities pattern explanation possible configurations causal flows and propositions. However, we hold such conclusions lightly, while maintaining both openness and degree of scepticism.

3.3 DEVELOP NEW SCENARIOS FOR ADDITIONAL PRODUCT MIX ANALYSES

The so-called "optimized" product mix output from 3.2 is the current best under a limited scope — no changes are made to the currently available equipment and resources. The real challenge of a product mix analysis is to create new business and production scenarios that frequently require major "structural" changes. The structural changes might involve the bold "re-engineering" of the business; for example, shutting down some portion of the operation thereby eliminating some product lines, or adding some product lines by realigning existing equipment/resources among several production sites or acquiring new equipment/resources etc. The principle concept behind the scenario development is to come up with a viable and feasible business plan and structure that will improve the bottom line. The scenario development is by far the most challenging part of a product mix study because it involves business strategy, breaking the existing product mix paradigm and invoking "outside-the-box" thinking to brainstorm good scenarios for the business to pursue.For each scenario, appropriate data will of course need to be added and incorporated into the existing data structure discussed in 3.2. Product mix analysis will need to be conducted for each scenario. Results will need to be evaluated for assessing the viability of the scenario. Frequently, the result of one analysis will direct the development of a new scenario for further analysis. In fact, product mix analysis is likely to be iterative in practical applications. If structural changes suggest acquisition, the same product mix analysis must be conducted assuming the acquisition has taken place. The merit of this possible acquisition can be assessed from the analyses by comparing product mix results with and without acquisition.

3.4 SELECT AN OPTIMAL PRODUCT MIX PROFILE

Since the product mix analysis involves entertaining multiple scenarios and the process of searching for the best scenario, the process is usually iterative. So in actual practice, 3.3 and 3.4 are closely linked. In this section, the following questions help the selection process:

Does the solution (i.e., the proposed product mix profile and the resultant profit estimate) meet the objective of the project?

What criteria are used for comparing various proposals and solutions?

In what ways are some product mix scenarios more desirable than others?

What are the pros and cons of each product mix scenario? How do the possible solutions relate to the original intent of the research?

What is the best solution?

Can we try out the possible solution on a small scale? (If piloting is possible, what data will we collect?)

Answering the above questions helps me to be objective in selecting the best product mix scenario and production profile. The mathematical programming that will help to answer the above question in making the best decision for the product mix scenario production profile, the researcher decided to settle on Linear programming as the mathematic model to be applied.

3.5 DEVELOPING THE MODEL

There are a variety of considerations that go into the development and implementation of an optimization model for manufacturing companies. We are going to highlight and comment upon a number of key issues and questions that should be addressed.

Any productivity optimization modelling starts with a specification of customer demand that is to be met by the production plan. Since most of these demands are not known, one relies on forecasting to determine future demand. To the extent that any forecast is inevitably inaccurate, one must decide how to account for or react to this demand uncertainty. The optimization models described in this study treat demand as being known; as such they must be periodically revised and rerun to account for forecast updates.

Productive models include decisions on production and inventory quantities. But in addition, there might be resource acquisition and allocation decision, such as adding to the work force and upgrading the training of the current work force.

It is important to construct to set a planning hierarchy. One structures the planning process in a hierarchical way by ordering thedecisions according to their relative importance. Hax and Meal (1975) introduced thenotion of hierarchical production planning and provide a specific framework for this,whereby there is an optimization model with each level of the hierarchy. Eachoptimization model imposes a constraint on the model at the next level of the hierarchy. Bitran and Tirupati (1993) provided a comprehensive survey of hierarchical planningmethods and models.

The identification of the relevant costs is also an important issue. For production modelling, one typically needs to determine the variable production costs, including setup related costs, inventory holding costs, and any relevant resource acquisition costs. Theremight also be costs associated with imperfect customer service, such as when demand isbackordered.

A decision problem exists because there are limited production resources that cannot bestored from period to period. Decision must be made as to which resources to include andhow to model their capacity and behaviour, and their costs. Also, there may be uncertaintyassociated with the production function, such as uncertain yields or lead times. Onemight only include the most critical or limiting resource in the planning problem. The first assumes a linear relationship between the production quantity and thesource consumption. The second assumes that there is a required fixed charge or setupto initiate production and then a linear relationship between the production quantity and resource usage.

Indeed, as noted above, the decision model must be periodically revised due to theuncertainties in the demand forecasts and production. For instance a firm might plan forthe next 26 weeks, but then revise this once a month to incorporate new information ondemand and production.

Productive optimization is usually done at an aggregate level, for both products andresources. Distinct but similar products are combined into aggregate product families thatcan be planned together so as to reduce complexity in the building of decision model. Similarly productionresources, such as distinct machines or labour pools, are aggregated into an aggregate machine or labour resource. Care is required when specifying these aggregates to assure that the resulting aggregate plan can be reasonably disaggregated into feasible production schedules.

Finally for complex products, one must decide the level and extent of the product structure to include in the production optimization process. For instance, in some contexts it is sufficient to just optimize the production of end items, the production optimization model for components and subassemblies is subservient to the master production schedule for end items. In other contexts, decision model for the end items is sub-optimal, as there are critical resource constraints applicable to multiple levels of the product structure. In this instance, a multistage decision model allows for the simultaneous planning of end items and components or subassemblies. Of course, this produces a much larger model.

The Mathematical Model Used

The mathematical tool used in the study is Linear Programming, since all variables inthe objective and constrain functions are all linear. Linear programming is the process of optimizing technique in order to simplify a task. An example would be to analyse the limitations of a task compared to the assets in order to determine the most efficient process to complete it.

Linear Programming Models

We develop the linear programming model for productivity optimization

We define the following notation

Decision variables

p_{it} production of item i during time period t

q_{it} inventory of item i at end of time period t

Parameters

T, I, K number of time periods, items, resources, respectively

a_{ik} amount of resource k required per unit of production of item i

b_{kt} amount of resource k available in period t

d_{it} demand for item i in period t

cp_{it} unit variable cost of production for item i in time period t

cq_{it} unit inventory holding cost for item i in time period t

We now formulate the linear program P1:

P1: $\text{Min}\sum_{t=1}^{T} \quad \sum_{i=1}^{I} cp_{it}\, p_{it} + cq_{it}\, q_{it}$ (1)

s t

$q_{i,t-1}+p_{it}-q_{it} = d_{it} \qquad \forall i, t$ (2)

$\sum_{i=1}^{I} a_{ik} p_{it} \leq b_{kt} \qquad \forall k, t$ (3)

$p_{it}, q_{it} \geq 0 \qquad \forall i, t$ (4)

The objective function (1) minimizes the variable production costs plus the inventory holding costs for all items over the planning horizon of T periods.

Equation (2) is a set of inventory balance constraints that equate the supply of an item in a period with its demand or usage. In any period, the supply for an item is the inventory from the prior period $q_{i,t-1}$, plus the production in the period p_{it}. This supply can be used to meet demand in the period d_{it}, or held in inventory as q_{it}. As we require the inventory to be non-negative, these constraints assure that demand is satisfied for each item in each period. We are given as input the initial inventory for each item, namely q_{i0}. Equation (3) is a set of resource constraints. Production in each period is limited by the availability of a set of shared resources, where production of one unit of item i requires a_{ik} units of resource k, for k = 1, 2, ... K. Typical resources are various types of labour, process and material handling equipment, and transportation modes.

The number of decision variables is 2IT, and the number of constraints is IT + KT. For any realistic problem size, we can solve P1 by any good linear-programming algorithm, such as the simplex method, excel solver.

We briefly describe next a number of important extensions to this basic model. We introduce these as if they were independent; however, we note that many contexts require a combination of these extensions.

Demand Planning: Lost Sales

For some problems we have the option of not meeting all demand in each time period. Indeed, there might not be sufficient resources to meet all demand. In effect, the demand parameters represent the demand potential, and the optimization problem is to decide what demand to meet and how. We assume that demand that cannot be met in a period is lost, thus reducing revenue. In addition, a firm might incur a loss of customer good will that would manifest itself in terms of reduced future sales. This lost sales cost is very difficult to quantify as it represents the future unknown impact from poor service today.

We pose a new optimization problem to maximize revenues net of the production, inventory and lost sales costs. We introduce additional notation and then state the model:

Decision variables

u_{it} unmet demand of item i during time period t

Parameters

r_{it} unit revenue for item i in period t

cu_{it} unit cost of not meeting demand for item i in time period t

P2: Max $\sum_{t=1}^{T} \sum_{i=1}^{I}[r_{it}(d_{it} - u_{it}) - cp_{it}p_{it} - cq_{it}\, q_{it} - cu_{it}\, u_{it}]$

s.t

$q_{i,t-1} + p_{it} - q_{it} + u_{it} = d_{it} \quad \forall i.t$

$\sum_{i=1}^{I} a_{ik} p_{it} \leq b_{kt} \qquad \forall k, t$

$p_{it}, q_{it}, u_{it} \geq 0 \qquad\qquad \forall i, t$

The objective function has been modified to include revenue as well as the cost of lost sales. The potential revenue, $\sum\sum r_{it}d_{it}$, is a constant and could be dropped in the objective function. In this case, we can restate the problem as a cost minimization problem, where the cost of lost sales includes the lost revenue.

Also, in P2, the inventory balance constraint has been modified to permit the option of not meeting demand; thus demand in a period can be met from production or inventory, or not satisfied at all.

Demand Planning: Backorders

A related problem variation is when it is possible to reschedule or backorder demand. That is, we might defer current demand until a later period, when it can be served from production. Of course there is a cost for doing this, which we term the backorder cost. Like the lost sales cost, the backorder cost includes hard-to-quantify costs due to loss of customer goodwill, as well as reduced revenue and additional processing or expediting costs due to the deferral of the demand fulfilment. We assume that this cost is linear in the number of backorders in each period.

We define additional notation and then state the model.

Decision variables

v_{it} backorder level for item i at end of time period t

Parameters

cv_{it} unit cost of backorder for item i in time period t

In comparison with P1, we now include a backorder cost on the objective function for P3.The inventory balance equation is modified to account for the backorders, which in effect behave like negative inventory. We typically would add a terminal constraint on the backorders at the end of the planning horizon; for instance, we might require $v_{it}= 0$, so that over the T-period planning horizon all demand is eventually met by the production plan. Any initial backorders, namely v_{i0}, can be dropped by adding them to the first period demand; that is, we restate the demand as $d_{i1} := d_{i1} + v_{i0}$, and then drop v_{i0}fromthe formulation.

P3: $\text{Min}\sum_{t=1}^{T} \quad \sum_{i=1}^{I} cp_{it}\, p_{it} + cq_{it}\, q_{it} + cv_{it}\, v_{it}$

s.t

$q_{i,t-1} - v_{i,t-1} + p_{it} - q_{it} + v_{it} = d_{it} \;\forall i.t$

$\sum_{i=1}^{I} a_{ik} p_{it} \leq b_{kt} \qquad \forall k,t$

$p_{it}, q_{it}, v_{it} \geq 0 \qquad \forall i,t$

In this formulation, when demand is backordered, the cost of this event is linear in the size and duration of the backorder. That is, if it takes n time periods to fill the backorder, the cost is proportional to n. In contrast, in some cases, the backorder cost might not depend on the duration but only on the occurrence and size of the backorder. We can modify this formulation for this case by defining a variable to represent new backorders in period t, given by max $[0, v_{it} - v_{i,t-1}]$; then we would apply the backorder cost to this variable in the objective function. This modification assumes that we fill backorders in a last-in, last-out fashion, as there is no incentive to do otherwise for this cost assumption.

Resource Planning

Up to now we have assumed that the resource levels are fixed and given. In some cases, an important element of the optimization problem is to decide how to adjust the resource levels over the planning horizon. For instance, one might be able to change the workforce level, by means of hiring and firing decisions. Hansmann and Hess (1960) provide an early example of this type of model.

Suppose for ease of notation that we have just one type of resource, namely the workforce. We introduce additional notation and then state the model:

Decision variables

w_t work force level in time period t

h_t change to work force level by hiring in time period t

f_t change to work force level by firing in time period t

Parameters

e_i amount oflabour required per unit of production of item i

cw_t variable unit cost of labour in time period t

ch_t variable hiring cost in time period t

cf_t variable firing cost in time period t

P4: Min $\sum_{t=1}^{T} cw_t w_t + ch_t h_t + cf_t f_t + \sum_{t=1}^{T} \sum_{i=1}^{I} [cp_{it}\, p_{it} + cq_{it}\, q_{it}]$

s.t

$q_{i,t-1} + p_{it} - q_{it} = d_{it}$ $\forall i.t$

$w_{t-1} + h_t - f_t - w_t = 0$ $\forall t$

$\sum_{i=1}^{I} e_i p_{it} - w_t \leq 0$ $\forall i, t$

$\sum_{i=1}^{I} a_{ik} p_{it} \leq b_{kt}$ $\forall k, t$

$p_{it}, q_{it}, w_t, h_t, f_t \geq 0$ $\forall i, t$

We add the variable cost for the work force to the objective function, along with costs forhiring and firing workers. The hiring cost includes costs for finding and attracting applicants as well as training costs. The firing cost includes costs of outplacement and retraining of displaced workers, as well as severance costs; there might also be a cost of lower productivity due to lower work-force morale, when firings or layoffs occur.

We restate theresource constraint, reflecting the work force as a decision variable and as the soleresource. We then add a new set of balance constraints for planning the work force: thework force in period t is that from the prior period plus new hires minus the number fired.

We have stated P4 for a single resource, representing the work force. The model extendsimmediately to include other resources that might be managed in a similar fashion overthe planning horizon. In addition, there might be other considerations to model such astime lags when adjusting a resource level. There might be limits on how quickly newworkers can be added due to training requirements. If there were limited trainingresources, then this imposes a constraint on h_t. Alternatively new hires might be lessproductive until they have acquired some experience.

3.6 SUMMARY

This chapter presented the research methodology of the study. In the next chapter, we shall address the data collected and analysis of the study.

CHAPTER 4

DATA COLLECTION AND ANALYSIS

4.0 INTRODUCTION

In chapter three we elaborate on the methodology the researcher used in analysing the research topic and how it will be implemented.Determining the best product mix that minimizes cost is one of the mostfundamental decisions that a company should make. If a company does not havesufficient capacity to satisfy the demand for its products, the best action would be that itshould use all of its existing resources and/or expand capacity through capital investmentto produce products with the highest profit.

Investigation in the existing decision model used indicates that, the approach in which demand is met is not systematic, in order way it is not gear toward a scientific approached of productivity optimization. They do not have any system to analysis which of their product generates a high cost of production and how to control its production with the intention of minimizing cost. They result to produce more of a particular product which increases their inventory holding cost, with some product lasting long till it is expires or becomes unusable. They do not consider the effect of unmet demand, the impact it will have on the company in the long round. That is lost of customer good will and most of the industries are dying because of their good will has been eroded with time. It came to light that, their major problem was allocation of limited resource to their various products considering future demand in order to control inventory cost, so as minimize production cost and maximize profit. They have no mechanism of determining how best to allocate resource to the various product, such decision is made without any scientific base-line and the manufacturer are left in with the mercy of circumstance, they method of production is not helping the company to grow.

Test of the Study

The block factory under study produces four types of block works. Each of the blocks is made up of sand, cement and water. The types of blocks are display as below.

16 X 8(5 inches) is represented by v and inventory of v is q1

16 X 9 (5 inches) is represented by x and inventory of x is q2

18 X 9 (6 inches) is represented by y and inventory of y is q3

Mouldings is represented by z and inventory z is q4

The following tables contain the data we gather from the factory.

Table 4:1 Data Collected for the Study

Type of Products (building blocks)	Resource for the product	Amount of Resource available at specified period	Amount of Resource for a unit of product	Cost of producing a unit of the product without labour	Cost of producing a unit of the product with labour	Initial Inventory	Inventory cost of a unit product	D f (f v
18X8	Sand	349	1.02	0.75	0.91	134	0.5	1
18X9	Sand	256	1.07	0.78	0.96	192	0.5	6
18X9(6inches)	Sand	292	1.15	0.84	1.03	239	0.5	9
Moulding	Sand	209	0.66	0.48	0.59	42	0.5	1
		1106						

amount of labour required per unit of production of item	variable unit cost of labour in time period	variable hiring cost for labour class in time period	variable firing cost for labour class in time period
.004	0.15	0.78	3.92
.004	0.15	0.58	2.88
.004	0.15	0.66	3.29
.003	0.1	0.31	1.57

Mathematical Formulation

Before we implement this problem statement in Excel, let's write out formulas corresponding to the table 4 above.

Minimize: $0.91v + 0.50q_1 + 0.96x + 0.50q_2 + 1.03y + 0.50q_3 + 0.55z + 0.2q_4$

s. t.

$134 + v - q_1 = 1006$

$192 + x - q_2 = 641$

$239 + y - q_3 = 954$

$42 + z - q_4 = 164$

$1.02v + 1.07x + 1.15y + 0.66z \leq 1106$

$v, x, y, q_1, q_2, q_3, q_4 \geq 0$

The Essential Steps

To define optimization model in Excel you'll follow these essential steps:

(i) Organize the data for your problem in the spreadsheet in a logical manner.

(ii) Choose a spreadsheet cell to hold the value of each decision variable in your model.

(iii) Create a spreadsheet formula in a cell that calculates the objective function for yourmodel.

(iv) Create formulas in cells to calculate the left hand sides of each constraint.

(v) Use the dialogs in Excel to tell Solver about your decision variables, the objective,constraints, and desired bounds on constraints and variables.

(vii) Run Solver to find the optimal solution.

Within this overall structure, you have a great deal of flexibility in how you choose cells to hold your model's decision variables and constraints, and which formulas and built-in functions you use. In general, your goal should be to create a spreadsheet that communicates its purpose in a clear and understandable manner.

Creating an Excel Worksheet

Now that we have organised data for the problem, in Excel the next step is to create a worksheet where the formula for the objective function and the constraints are calculated. Because decision variables and constraints usually come in logical groups, you will often want to use cell ranges in the spreadsheet to represent them.

We click on the Solver button on the Data tab, on the Add-In tab which displays the Solver Parameters dialog.

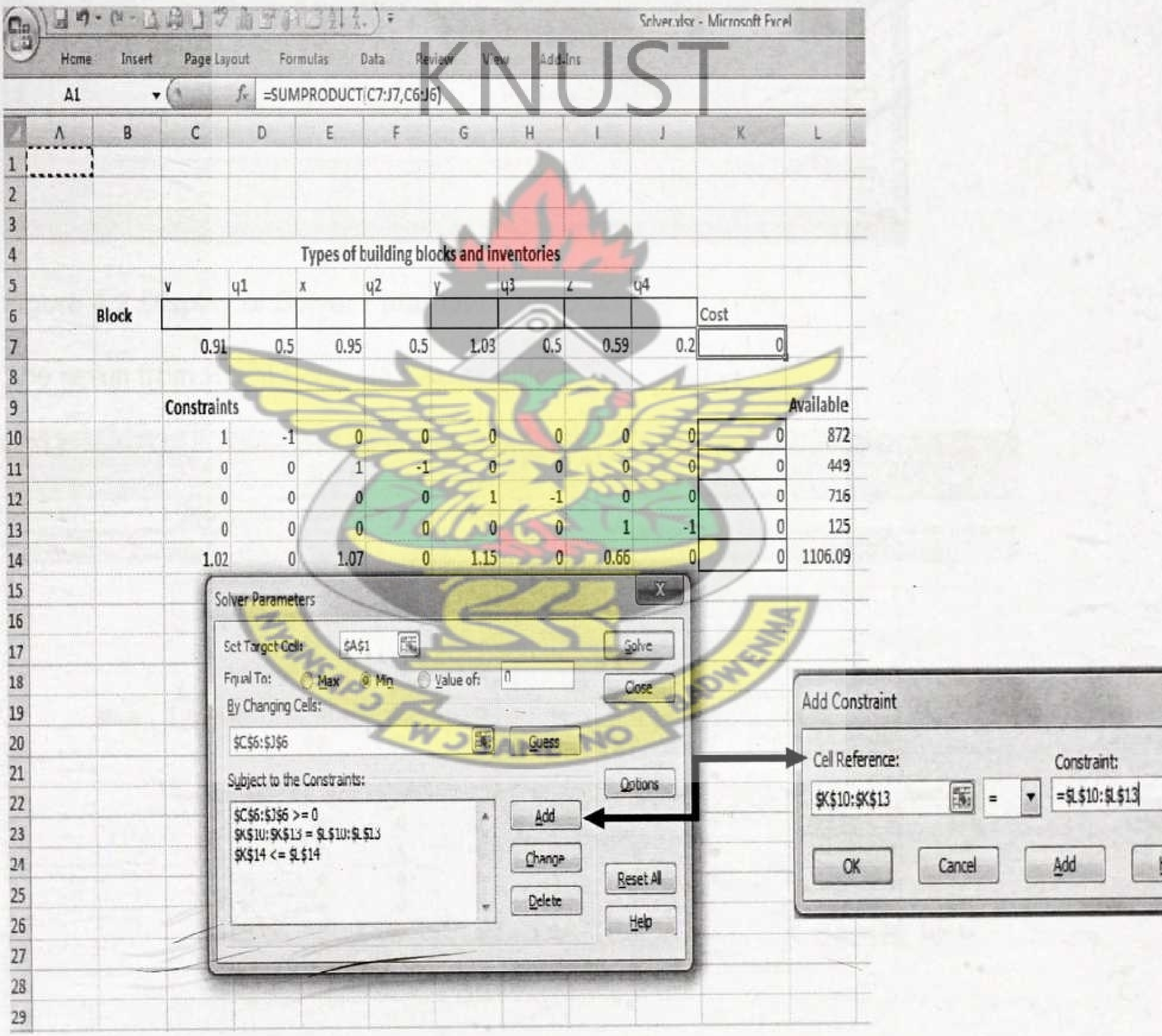


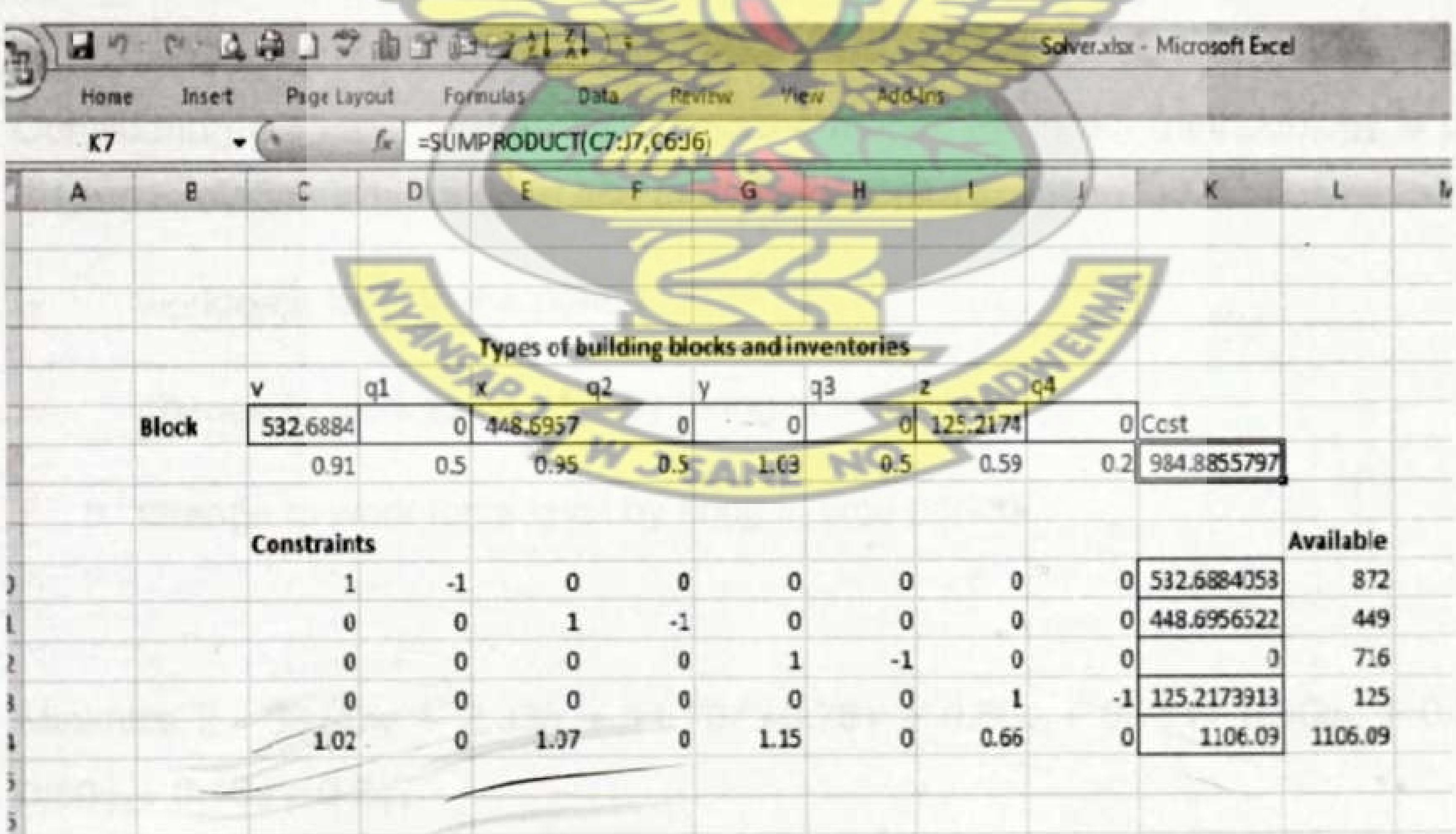
Figure 4.1 Display of objective function and constrains

Click on the Add button on the Solver Parameters dialog to display the Add Constraint dialog.

This is how the Solver Parameter dialog looks like when all the entries are completed.

Figure 4.2 Display of Solver Parameters windows

The result from Excel Solver is display below.



Types of building blocks and inventories

	v	q1	x	q2	y	q3	z	q4		
Block	532.6884	0	448.6957	0	0	0	125.2174	0	Cost	
	0.91	0.5	0.95	0.5	1.03	0.5	0.59	0.2	984.8855797	
	Constraints									Available
	1	-1	0	0	0	0	0	0	532.6884053	872
	0	0	1	-1	0	0	0	0	448.6956522	449
	0	0	0	0	1	-1	0	0	0	716
	0	0	0	0	0	0	1	-1	125.2173913	125
	1.02	0	1.07	0	1.15	0	0.66	0	1106.09	1106.09

Figure 4.3 Display of result of the decision model

Given that the Block factory have limited resource at the specify period, of one week and the level of demand already forecasted. It was up to the manufacturer to make the best decision,as how best to meet demand with the limited resource at a minimized cost.

From our result the manufacturer could not meet all the demand, 533blocks of 18x8(5inches) was supply instead of 872, all 449 of 18X9(5inches) blocks was supply, none of 18X9(6inches) was produce and all of demand for mouldings were met. This value is exclusion of the initial inventory; it is the additional production that was needed to satisfy the demand for the period.

Till now we have considered the level of resource to be fixed and given. For instance one might decide to change labour force by means of hiring and firing. Noting the rate of hiring is 70 to 200 percent of the existing employee's annual salary (http://corporatesocialresponsibilitygh.com/?p=64), and cost of firing express in weekly wages. One month is recorded as 4 1/3 weeks

(http://www.nationmaster.com/graph/lab_fir_cos_wee_of_wag-labor-firing-cost-weeks-wages).

Suppose we just want to think about one type of resource namely the work force. Considering our table of data fig 3, and the model, P4 in our methodology is used. Addition notation is introduced and model developed as follow.

w workforce level in the period

h change to work force level by hiring in time period

f change to work force level by firing in time period

Minimize Z= $38.90w + 2.33h + 11.70f + 0.75v + 0.50q_1 + 0.78x + 0.50q_2 + 0.84y + 0.50q_3 + 0.48z + 0.2q_4$

s.t

$134 + v - q_1 = 1006$

$192 + x - q_2 = 641$

$$239 + y - q_3 = 954$$

$$42 + z - q_4 = 164$$

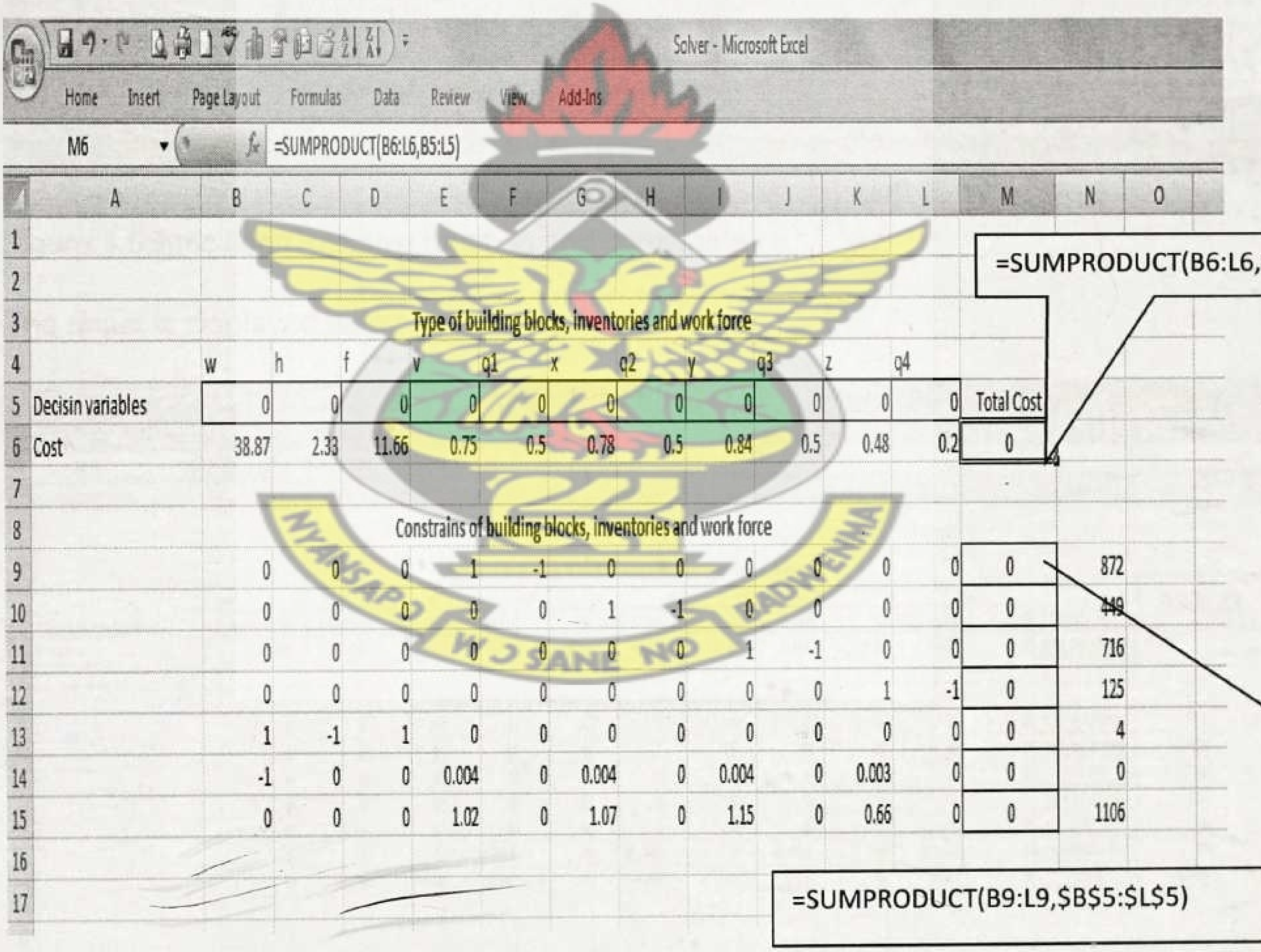
$$0.004v + 0.004x + 0.004y + 0.003z - w \leq 0$$

$$1.02v + 1.07x + 1.15y + 0.66z \leq 1106$$

$$h + f + w = 4$$

$$v, x, y, z, w, h, f, \geq 0$$

Applying Excel solver for the above linear programming, the table below represent the objective and constrains.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2														
3					Type of building blocks, inventories and work force									
4		w	h	f	v	q1	x	q2	y	q3	z	q4		
5	Decisin variables	0	0	0	0	0	0	0	0	0	0	0	Total Cost	
6	Cost	38.87	2.33	11.66	0.75	0.5	0.78	0.5	0.84	0.5	0.48	0.2	0	
7														
8					Constrains of building blocks, inventories and work force									
9		0	0	0	1	-1	0	0	0	0	0	0	0	872
10		0	0	0	0	0	1	-1	0	0	0	0	0	449
11		0	0	0	0	0	0	0	1	-1	0	0	0	716
12		0	0	0	0	0	0	0	0	0	1	-1	0	125
13		1	-1	1	0	0	0	0	0	0	0	0	0	4
14		-1	0	0	0.004	0	0.004	0	0.004	0	0.003	0	0	0
15		0	0	0	1.02	0	1.07	0	1.15	0	0.66	0	0	1106
16														
17														

Figure 4.4 Inputs for the Productive Optimization parameters

The next screen displays the objective function and its constrains, as it has been inputted in the Excel Solver dialog box

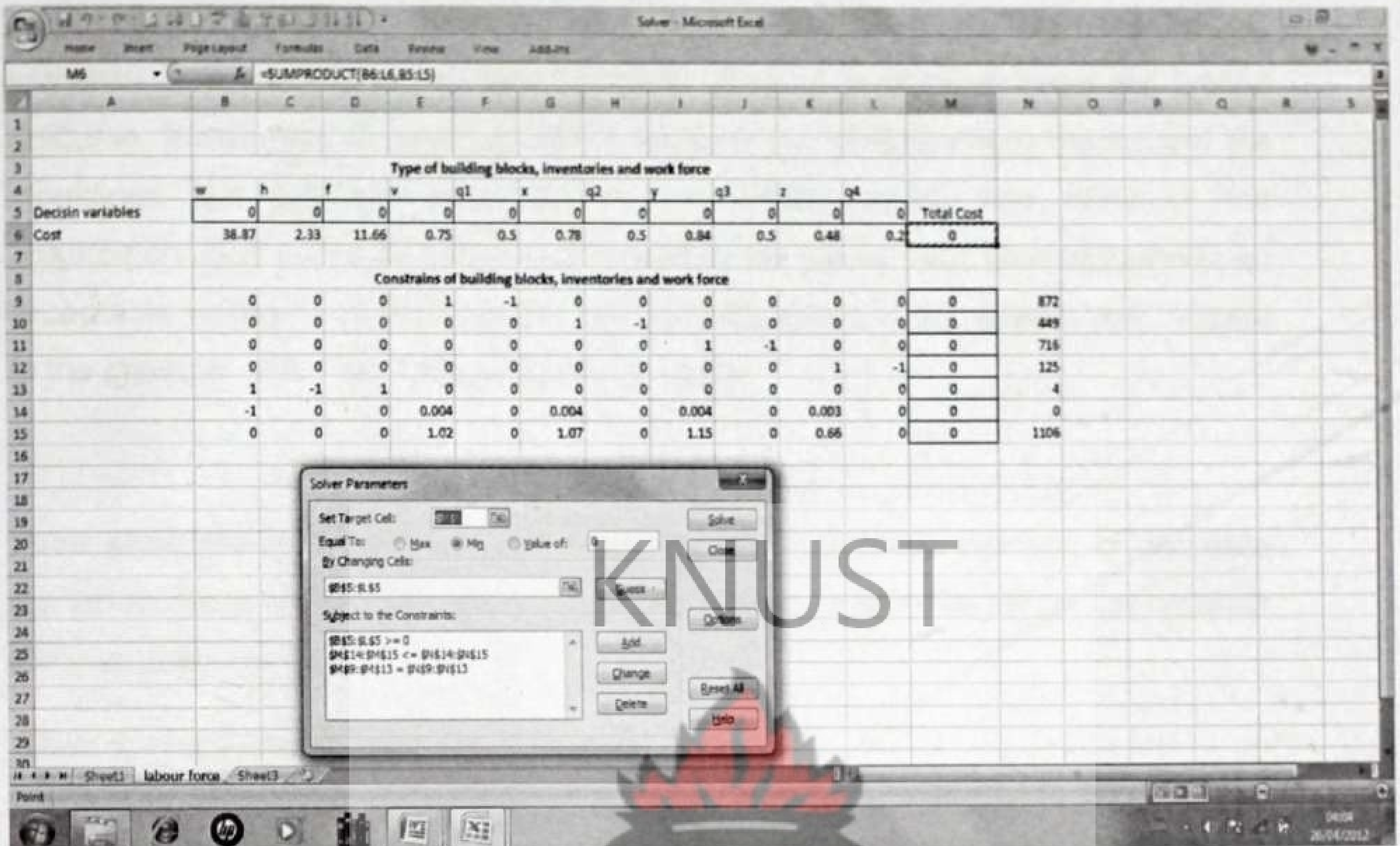


Figure 4.5Specified Objective function and constrains

The result is displayed below,

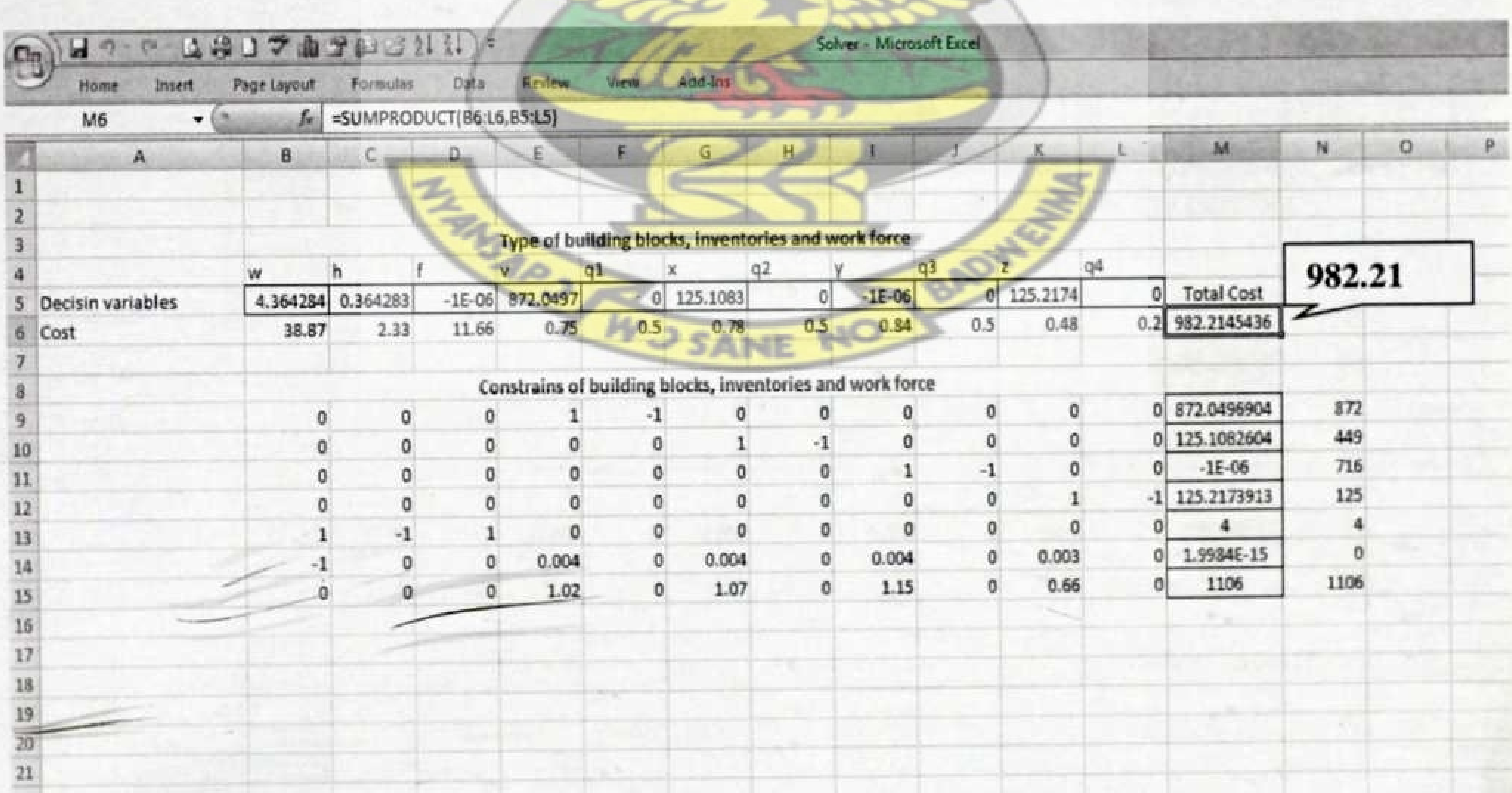


Figure 4.6 Result of the optimization

Analysing the result of the linear programming model above, we realised the company is producing at the best minimum cost of production given the limited resource. It was able to meet up all the demand for 18X8(5inches) blocks and the mouldings but produce only 125 of the 18X9(5inches) and none of the 18X9(6inches) at minimum cost 982. Remember the labour force level of four was an acceptable decision.Let consider the following scenarios, if the system can indicate to the producer when the wrong decision is made.

Think about the instance when the company decide to either increase or decrease the labour force level under where other parameters remain the same. Let consider the two tables below;

When the labour force is increase from four to six

Solver - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Add-Ins

M6 =SUMPRODUCT(B6:L6,B5:L5)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3					Type of building blocks, inventories and work force										
4		w	h	f	v	q1	x	q2	y	q3	z	q4			
5	Decisin variables	4.300835	0	1.699165	532.6002	0	448.6957	0	-1E-06	0	125.2174	0	Total Cost	996.52	
6	Cost	38.87	2.33	11.66	0.75	0.5	0.78	0.5	0.84	0.5	0.48	0.2	996.5228174		
7															
8					Constrains of building blocks, inventories and work force										
9		0	0	0	1	-1	0	0	0	0	0	0	532.6001706	872	
10		0	0	0	0	0	1	-1	0	0	0	0	448.6956532	449	
11		0	0	0	0	0	0	0	1	-1	0	0	-1E-06	716	
12		0	0	0	0	0	0	0	0	0	1	-1	125.2173913	125	
13		1	-1	1	0	0	0	0	0	0	0	0	6	6	
14		-1	0	0	0.004	0	0.004	0	0.004	0	0.003	0	-1.88203E-11	0	
15		0	0	0	1.02	0	1.07	0	1.15	0	0.66	0	1106	1106	
16															
17															
18															
19															

Figure 4.7 Result of an increase in size of a variable resource

If the labours force level is decrease from four to two

	Type of building blocks, inventories and work force												
	w	h	f	v	q1	x	q2	y	q3	z	q4		
Decisin variables	4.364284	2.364284	0	872.0497	0	125.1083	0	-1E-06	0	125.2174	0	Total Cost	986.87
Cost	38.87	2.33	11.66	0.75	0.5	0.78	0.5	0.84	0.5	0.48	0.2	986.8745576	
	Constrains of building blocks, inventories and work force												
	0	0	0	1	-1	0	0	0	0	0	0	872.0496904	872
	0	0	0	0	0	1	-1	0	0	0	0	125.1082604	449
	0	0	0	0	0	0	0	1	-1	0	0	-1E-06	716
	0	0	0	0	0	0	0	0	0	1	-1	125.2173913	125
	1	-1	1	0	0	0	0	0	0	0	0	2	2
	-1	0	0	0.004	0	0.004	0	0.004	0	0.003	0	3.33067E-16	0
	0	0	0	1.02	0	1.07	0	1.15	0	0.66	0	1106	1106

Figure 4.8 Result of decrease in size of a variable resource

From Figure 4.7 we realised the cost of production went up compare to when the labour force was four. The model also indicated to the manufacturer to fire approximately two of his staffs. The labour force is too large for the company at this period given the limited resource available. If the company maintain the staffs level it will being producing at a higher cost which will affect its revenue, in other words this decisions model if applied will not improve productivity.

Equally looking into Figure 4.8, where the labour force level was reduce from four to two also had it difficulties since the cost of production is higher than when the staffs level was four. The company is advised to increase labour by two hence the cost of hiring labour has to be borne by the company, increasing its cost of production. Yet, this decision is not best practice for productivity optimization.

The decision model used in this study is not applicable to only labour, other resource like machinery, raw materials can be introduced into the model for best solution. Nevertheless, applying decision model to productivity optimization is one of the instruments that manufacturers can implement to increase productivity. It enablesmanufacturers to properly allocate limited resources in a typical product-mix environment.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.0 CONCLUSION

In this chapter, we draw conclusion from the study and make recommendations for future research, as well as recommend on how decision models may be integrated into the manufacturing sector to ensure productivity optimisation and improvement in Ghana's economy.

From the study we observed and conclude on the underlisted points

(i) Cost of production is higher when the optimal decision variable (Labour force) is either increase or decrease

- Hiring cost increases cost of production when labour level is decrease
- Firing cost increases cost of production when labour level is increase

(ii) The quantity of items produce when labour level was 4 or 2 is higher than when it was 6, because the latest resource allocation is not optimal.

(iii) The cost of production was less when we single out, labour force as a resource to optimize it allocation, than when the allocations of resource were all treated together.

5.1 BENEFITS THAT MAY BE DERIVE FROM THE STUDY

It is obvious from the study that the benefits of applying decision model to productivity optimisation are well known to the manufacturing sector and represent a formidable force to drive the adoption by many companies in Ghana. The general reorganisation of the positive impact of productivity optimisation is to reduce the cost of doing business, properly allocation of limited resource, improve productivity, meets customers' demand, speed and accuracy delivery of service.

In the view of the enumerated benefits, responding companies have come to accept application of decision model to productivity optimisation as a novelty that has a very great potential of improving their production.

5.2 BARRIER TO THE STUDY

Provision of relevant data on some of the parameter for the study was difficult to assess from the manufacturer, because such a data has never be captured. This made analysing and implementation of the productivity optimization model quite difficult to reflect reality of situation. For instance cost of firing or losing an experience worker, which the company might have spent on his training or with long years of working experience.

From our study, the prominent perceived barrier to the adoption of the productivity optimization model by the respondents was their preference for established business model and cost factors. Production managers seems to be comfortable with existing way of production method and are not readily in position to accept new business model easily. Most a time, they consider the model to be more of mathematics and think is prevalent for only those well vast in mathematics to adopt and implement. Hence discourage them from using such a significant model.

The purpose of the study was to meet customers' demand by appropriately allocating limited resource to maximize profit or minimize cost. Yet future demand is best known in only partials and often is not known at all. Consequently, one relies on forecast which is inevitably inaccurate.One must then account for or react to this demand uncertainty. This model treat demand as being known, as such they must be periodically revised and return to the account of forecast updates.

5.3 RECOMMENDATION

The study is high recommended for the manufacturing sector, it will facilitate the decisions making in their businesses directly on production systems. Adopting and implementing the study will make their businesses more efficient because planning and controlling production can easily be done in ease which saves time and cost. Production managers' hurdle on how best resources should be allocated is completely being taken care of and recommends it usage since it will improve productivity.

The study did not include the model of a single aggregate product with quadratic cost and multi-item, capacitated a lot-size problem which can be modelled as a mix integer linear programming. This is important model as it introduces economies of scale in production, due to the presence of production setup and recommends future study to consider this model.

We will recommend future study on continuous-time model since the study considered only discrete-time model.

REFERENCES

Amar, A.D (1995). "Principled Versus Analytical Decision-Making: Definitive Optimization." Mid-Atlantic Journal of Business.

Bieker (2006): A Real Time Production Optimization Of Offshore Oil And Gas Production System.

Bitran, G. R. and D. Tirupati (1993), "Hierarchical Production Planning," In Handbooks in Operations Research and Management Science, Volume 4, Logistics of Production and Inventory, edited by S. C. Graves, A. H. G. RinnooyKan and P. H. Zipkin, Amsterdam, Elsevier Science Publishers B. V., pp. 523-568.

Boston: Prindle, Weber and Schmidt (1969), "Eves In Mathematical Circle".

Crainer, Stuart (1998). "The 75 Greatest Management Decisions Ever Made." Management Review.

Cynthia M. Pavett and Alan W. Lau, "The Influence Of Hierarchical Level And Functions,"

Drucker, Peter F (2004). "What Makes an Effective Executive." Harvard Business Review "Effective Executives Follow Eight Practices." Association Management.

Eisenhardt, Kathleen M (1998). "Strategy as Strategic Decision Making." Sloan Management Review, Spring, 65.

Encyclopedia of Management, ©2006 Gale Cengage. All Rights Reserve

Ettore, Barbara (1998). "Absolutely Great Decisions." Management Review,

G. RinnooyKan and P. H. Zipkin (1993), Amsterdam, Elsevier Science Publishers B. V., pp. 371-443.

George Polya (1945), "How To Solve IT,"

Graves, S. C. (1981), "A Review of Production Scheduling," Operations Research, Vol.29, No. 4 pp. 646-675.

Hackman, S. T. and R. C. Leachman (1989), "A General Framework for Modeling Production," Management Science, Vol. 35, No. 4, pp. 478-495.

Hammond, John S., et al (1998). "The Hidden Traps in Decision Making" Harvard Business Review.

Hammond, John, et al. Smart Choices (1999): A Practical Guide to Making Better Decisions. Boston: Harvard Business School Press.

Hansmann, F. and S. W. Hess (1960), "A Linear Programming Approach to Production and Employment Scheduling," Management Technology, Vol. 1, No. 1, pp. 46-5.Hax, A. C. and H. C. Meal, ""Hierarchical Integration of Production Planning and Scheduling," In Studies in Management Sciences, Vol. 1: Logistics, edited by M.A

James R. Newman (1956), "The World of Mathematics published by Simon and Schmidt,"

Joseph Prokopenkom (1987), "Productivity Management."

Lasdon, L. S. and R. C. Terjung (1971), "An Efficient Algorithm for Multi-Item Scheduling," Operations Research, Vol. 19, No. 4, pp. 946-969.

Magnanti, T. L, J. F. Shapiro, and M. H. Wagner (1976), "Generalized Linear Programming Solves the Dual," Management Science, Vol. 22, No. 11, pp.1195-1203.26 Shapiro, J. F., "Mathematical Programming Models and Methods for Production Planning and Scheduling," In Handbooks in Operations Research and Management Science, Volume 4, Logistics of Production and Inventory, edited by S.C. Graves, A.H.

MukeshSardhara&BinalKapadia (2008), Productivity & Improvement In Productivity

PandianVasant, Nadir Barsoum (2007): In Fuzzy Optimization of Cost Function Product Mix.

Pethokoukis, James M. (2004), "All Seeing All Knowing (Creating Futures Markets to Aid in Corporate Decision Making)."U.S. News & World Report.

Phillips-Wren, Gloria E., Eugene D. Hahn, and Guisseppi A. Forgionne (2004)"A Multiple-Criteria Framework for Evaluation of Decision Support Systems."Omega.

Ralph L. Keeney Smart Choices (1998), “A Practical Guide to Making Better Decisions,”

Roy, .A, Falomir, E. E., Lasbon, L.,“An Optimization-based decision Support System For A Product Mix,”

Sardina and Vrat (1987), “Handbook on Knowledge Management.”

Silver, E. A., D. F. Pyke, and R. Peterson (1998), Inventory Management and Production Planning and Scheduling, 3rd Edition, New York, John Wiley Inc..

Thomas. L. J. and J. O. McClain (1993), “An Overview of Production Planning,” In Handbooks in Operations Research and Management Science, Volume 4, Logistics of Production and Inventory, edited by S. C. Graves, A. H. G. RinnooyKan and P. H. Zipkin, Amsterdam, Elsevier Science Publishers B. V., pp. 333-370.

Trigeiro, W. W., L. J. Thomas and J. O. McClain (1989), “Capacitated Lot Sizing with Setup Times,” Management Science, Vol. 35, No. 3 pp. 353–366.

Vollman, T. E., W. L. Berry and D. C. Whybark (1992), Manufacturing Planning and Control Systems, 3rd edition, Burr Ridge Ill., Richard D. Irwin Inc.

Wagner, H. M. and T. Whitin (1958), “Dynamic Version of the Economic Lot Size Model,” Management Science, Vol. 5, No. 1, pp. 89-96.

Zheng Wen, Louis J. Darlofsky, Benjamin Van Roy (2011), “Use Of Approximate Dynamic Programming For Production Optimization.”

http://www.enotes.com/decision-making-reference

http://www.referenceforbusiness.com/management