MEASURING THE EFFICIENCY OF WORLD VISION GHANA'S EDUCATIONAL PROJECTS

Using Data Envelopment Analysis

by

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DECLARATION

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

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Head of Department	Signature	Date

DEDICATION

This work is dedicated to my wife and children, Regina, Nathan and Benaiah, all my siblings and all my church members especially Pastor Robert Akolbugri, Peter Awaab, Peter Paul Dakora, Emmanuel Owusu, Jonas Salifu and Emmanuel Banye for their moral support.

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The greatest thanks goes to God for making it possible for me to get this far.

ABSTRACT

In the current era, donors are more interested in value for their money and are now keener about how their hard earned money is being used. As such Non-governmental organisations face crucial decisions as resources become scarcer. Based on these, more efficient use of resources becomes more important than ever before. This thesis therefore evaluates the performance of Educational Projects of four Area Development Programmes of World Vision Ghana using Data Envelopment Analysis Approach. The Data for the four Area Development Programmes and their respective District Education Offices for the years 2009 and 2010 were obtained. The two inputs that were recognised are number of staff and number of vehicles. We also identified two outputs as BECE pass rate and completion rate at JHS level. The results revealed that in 2009 and 2010 three Area Development Programmes and two Area Development Programmes were identified as efficient respectively. One Area Development Programme and two Area Development Programmes were marked out as inefficient in the years 2009 and 2010 respectively. To improve the performance of any inefficient Area Development Programme one of the efficient ADP was set as a benchmark.

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LIST OF ACRONYMS

ADP= Area Development Programme

BECE= Basic Education Certificate Examination

CCR= Charnes, Cooper and Rhodes

CIDA= Canadian International Development Agency

DEA= Data Envelopment Analysis

DMU= Decision Making Unit

UNESCO= United Nations Education Scientific and Cultural Organisation

WV= World Vision

CHAPTER ONE

INTRODUCTION

Resource efficiency underpins every decision pertaining to development programmes. Against this backdrop, all human entities—be they governmental or non-governmental—make decisions based on the most appropriate modalities for resource efficiency.

The problem of resource scarcity is more pronounced in the three Northern regions of Ghana than its counterpart regions. According to CIDA (2008), poverty levels in these three regions (that is the Northern, Upper-West and Upper East Regions) range between 52% in the Northern Region and 88% in the Upper West Region. In these regions, key indices like access to education, health care, safe drinking water and child nutrition are below national average.

In light of these challenges, World Vision Ghana, a Christian relief, development and advocacy organisation has set up a number of poverty alleviation interventions aimed at developing its catchment areas. World Vision's operations in Ghana started in 1979. The main sectors of their intervention include, education, health, water, sanitation and hygiene (WASH), agriculture and food security, humanitarian and emergency affairs (HEA), micro-enterprise development activities, gender and development as well as Christian commitment.

Since its inception in 1979, World Vision has impacted several lives in Ghana. However, the problem of acute poverty in Northern Ghana still persists. This coupled with the fact that the scarce resources usually employed in these developmental interventions are gotten from international donors communities mostly in developed countries. In light of this, a research into the extent to which these hard-earned resources are efficiently used in poverty alleviation is more important than ever before.

Vota (2011) added that United States Agency for International Development (USAID), the Australian Agency for International Development (AusAID), and World Vision (collectively referred to as the "Founding Partners") are seeking game-changing innovations with the potential to dramatically improve reading skills and low literacy rates among primary grade children.

Over the past decade, governments in many countries and the international community have rallied around Millennium Development Goal 2: ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling. As a result, there have been significant increases in primary enrollment worldwide, particularly in low income countries. However, learning levels are very low. In Mali, Pakistan and Peru, for example, more than 70% of children in the primary grades could not read at grade level and many could not read a single word after two or more years of schooling.

World Vision invests more than US $250 million per year in education and focuses on

impact for children and youth ages 3-18 through four strategic objectives that foster the development of functional literacy, math and essential life skills as key outcomes of education:

1) increase children's access to equitable, quality and sustainable early childhood education and primary education, with special attention to the most vulnerable groups;

2) strengthen community involvement in the education for all children;

3) increase youth's access to quality educational opportunities, with focus on out-of-school youth; and

4) foster enabling environment for learning through partnership and advocacy with communities, governments, private sector, universities, donors and civil society organizations.

Considering the above submission by Vota (2011), as well as the huge amount of time and money World Vision invests in education, it is prudent to assess the best way in which World Vision's inputs especially in the area of education are being maximized.

DEFINITION OF KEY TERMINOLOGIES

Vlasceanu et al. (2004), in writing on UNESCO's regular journal defines efficiency as an ability to perform well or to achieve a result without wasted resources, effort, time or money (using the smallest quantity of resources possible). This definition, though good, does not discuss the best combination of inputs and its resultant outputs. Thursby (2000) thus added a wider dimension to the definition of efficiency by viewing it as follows; a

department is deemed technically efficient if, when compared to departments with similar levels of inputs, it could produce greater outputs without increasing its inputs usage or equivalently, it is one which compared to departments with similar levels of output, could produce the current levels of output with fewer inputs. Efficiency therefore is defined as obtaining the maximum possible output or outcome for a given set of inputs.

Efficiency can also simply be defined as the measure of outputs over inputs. However, in terms of its usages in DEA, it is said that DMU is fully efficient if and only if it is not possible to improve any input or output without worsening some other input or output.(Pareto,1909; Koopmans,1951).

Before we proceed, we must first clarify some terminology so that we can be more precise in our language. Hasnul (2002) stated that there has been confusion and lack of consistency in the use of the term efficiency and effectiveness. Simply, effectiveness is associated with attainment of predetermined goals (i.e. outputs) whereas efficiency is related to use of resources in the attainment of outputs. Figure 1 shows the various possible locations of various water companies. The target or goal is to be at location E on PQ (Efficiency frontier) and where the authority is both efficient and effective. At location F (the water authority is efficient and over effective) but at location D (the water authority is efficient but ineffective). Company C is neither efficient no effective, Company A is over effective but in efficient and company B is effective but inefficient.

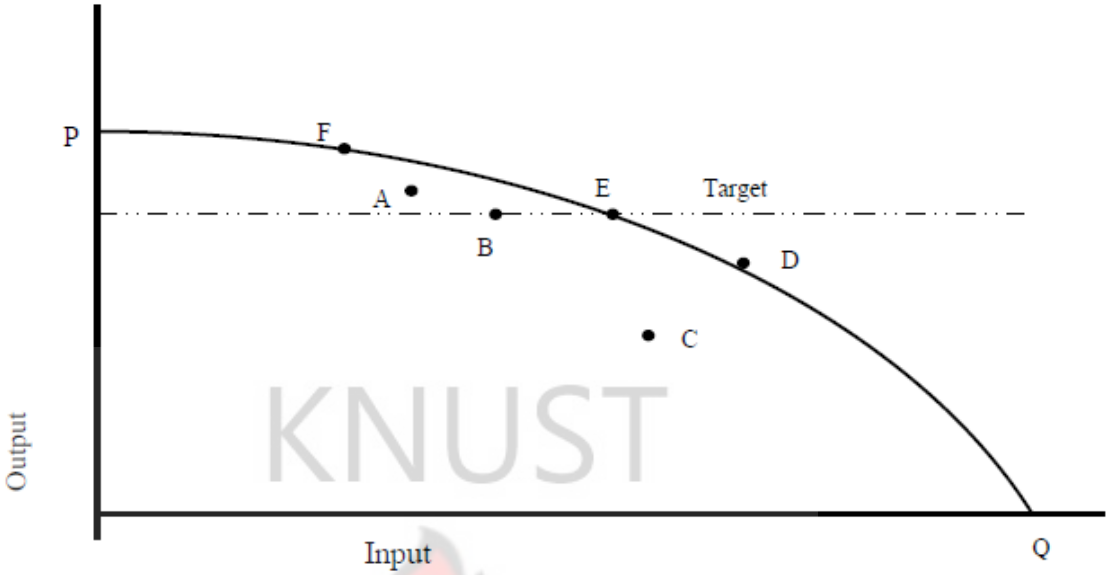

Figure 1 Efficiency and effectiveness

Source: Bouchart, F. C., Hasnul, M.S,

Within the context of education, technical efficiency may refer to the physical relationship between the resources used (say labour and equipment) and some education outcome.. In order to improve technical efficiency, institutions should be able to identify the sources of misperformances and the alternatives available to make better use of their resources. Therefore, the question to be answered is "how can an institution become efficient in practice?".

Frei and Harker (1996) argue that traditional efficiency studies measure the performance of an institution by its ability to transform inputs to outputs. However, the actual way in which these inputs are transformed to outputs is often overlooked. That is, each institution's operation is conceptualized as a black box: inputs go in, outputs come out,

and little analytical attention is paid to the inner workings of the transformation process. This paper examines this "black box" and argues that the actual design of the transformation process is a critical component in the performance of a firm. Further, this paper submits that the design of the transformation mechanism, or the process design, must be fully studied and integrated into performance analysis in order to provide useful managerial recommendations.

According to Madl et al. (2008) the analysis of efficiency is about the relationships between inputs and outputs. In 1957, Farrell already investigated the question how to measure efficiency and highlighted its relevance for economic policy makers. It is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources. Since that time techniques to measure efficiency have improved and investigations of efficiency have become more frequent, particularly in industry. This study thus seeks to inform policy makers and development agents on how to increase output without necessarily increasing or spending more on input.

In the private sector, the overriding measure of performance is profit. Performance ratios are widely used throughout all sectors of business and commerce. The best known ratios are for financial and production. Ratios on its own conveys little information; it needs to be compared with, or put into the context of, some other number, measuring either a similar quantity in another organisation (or the same quantity for another time period) or a related quantity in the organisation.

Organisations have become increasingly concerned about the value they are receiving for their money. The traditional approach of throwing money at problems is no longer acceptable. People increasingly expect fair value for their money. They also expect the services provided to be of top quality and to enhance their quality of life. But how do we measure quality? In the past, organization performance has generally been defined in terms of what it has done (e.g. amount of funding provided, number of schools provided with material). But these measures focus on how "busy" organisation has been, rather than what it has achieved. Claiming success based upon program demand is not a valid indicator as there are usually no alternatives to publicly provided services. And tracking the amount of money spent to provide a service won't indicate if the organisation is making progress in solving problems. Thus, assessing performance should focus less on program inputs (e.g. Staffing) and the outcomes of activity. In short, we should try to determine what works, what doesn't and why. As we learn more, organization inputs can be adjusted and available resources allocated to the programs that produce the best results. Given the reduction in available resources, it is important that programs be delivered efficiently, and imperative that they be effective in producing the desired benefits or results

EDUCATION

Education is the best investment for the people because well educated people have more opportunities to get a job which gives them satisfaction. Educated individuals enjoy respect among their colleagues and they can effectively contribute to the development of their country and society by inventing new devices and discoveries. Today's ever

growing numbers of people mostly are not satisfied with their basic education and try to get secondary or tertiary educational institutions and some search additional information on the internet.

Atchoarene and Gasperini (2003) also contend that, it is accepted that farmers with basic education are more likely to adopt new technology and become more productive. With basic education they are better equipped to make more informed decisions for their lives and for their communities and to be active participants in promoting the economic, social and cultural dimensions of development. It is equally accepted that excess rural labour has to find work outside the farm, whether in rural or urban settings and that without basic literacy and numeracy, individuals are unlikely to be hired for anything more than basic wage labour. A community cannot foster development without an educated population. Businesses, large or small, are unlikely to choose to invest in rural areas if skilled or trainable human resources are unavailable. Similarly, a community cannot retain educated people without an attractive economic environment. Many poor rural areas, mostly but not only in developing countries, are trapped in this situation. Recognizing the central importance of this dilemma, this publication chooses to adopt a dual approach combining, as much as possible, the rural development perspective with educational issues. It is clear to the world development community that a multisectoral and multi-disciplinary approach is needed to reduce rural poverty and that we need to work together if we are to be successful in our goal. While there is at present no single solution to the alleviation of rural poverty, education and training are critical elements. Growth needs to be achieved with equity and rural dwellers need to have the capacity to

be participants in the labour market and in society. Education and training are two of the most powerful weapons in the fight against rural poverty and for rural development. Unfortunately, these are also among the most neglected aspects of rural development interventions by national governments and by donors.

In an era of limited resources and wavering citizen confidence in public education, development partners such as World Vision International as well as their donors, are asking to see demonstrable returns on their education investments. They want assurance that schools are using resources efficiently to increase student achievement. Consequently both international donors and World Vision Ghana want sound information that will give them value for their effort. This will also guide World Vision Ghana in the allocation and combination of their resources in the various sectors.

BACKGROUND OF DATA ENVELOPMENT ANALYSIS

Charnes et al (1978) were the first to introduce the DEA as a multi-factor productivity analysis module for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). The DEA-technique requires a large number of medium-sized linear programming problems to be solved. In particular, when DEA- analysis is performed interactively, the problems have to be solved rapidly while the decision maker is waiting. The principle of this non parametric method is based on two important sets of multiple variables called inputs and outputs variables.

The DEA is a linear programming methodology that measures the efficiency of multiple decision making units when the resultant process presents a structure of multiple inputs and outputs. The units analysed are called decision-making units (DMUs). The DEA model was developed by Charnes et al. (1978) and Banker et al. (1989). DEA is a method used for the measurement of efficiency in cases where multiple input and output factors are observed and when it is not possible to turn this into one aggregate output or output factor. DEA is receiving increased importance as a tool for evaluating and improving performance of service operations. It has been extensively applied in performance evaluation and benchmarking of schools, hospitals, banks etc. (Charnes et al, 1994).

DEA is a technique for measuring efficiency. It does not consider the units of measurement of an input. In fact, DEA handles inputs and outputs measured in different units. The measurement of performance has created uncertainty by the lack of an agreed appropriate analytical tool. The current method of evaluating and monitoring performance for example financial and operational, physical and personnel factors are made separately without bringing together the inputs and outputs into a single measure of performance.

In simple terms, DEA takes a collection of similar entities, which can be anything from banks to hospitals, and refers to them as Decision Making Units (DMU). Data from these DMUs is broken down in to inputs and outputs. A linear programming technique is then used to determine the weights for each input and output that is most beneficial to an individual DMU. This process allows all DMUs to identify their ideal weights for each input and output. Once these weights are set, a ratio measure of the weighted

inputs and outputs is formed, and the DMUs are compared with respect to that measure. The idea behind this technique is that each DMU is able to grade itself in a fashion that is most favorable to its situation. All of the DMUs ratio measures are then compared to determine which DMUs are most efficient given their resources and outputs. Efficiency is determined by the distance of that measure from the frontier created by the most efficient DMUs.

DEA allows the calculation of technical efficiency measures that can be either input or output oriented. The purpose of an output-oriented study is to evaluate by how much output quantities can be proportionally increased without changing the input quantities used. This is the perspective taken in this paper. Note, however, that one could also try to assess by how much input quantities can be reduced without varying the output. The two measures provide the same results under constant returns to scale but give different values under variable returns to scale. Nevertheless, both output and input-oriented models will identify the same set of efficient/inefficient producers. This study seeks to measure efficiency without necessarily increasing inputs but seeks to get the highest efficiency by best combination of the available inputs.

In addition to being a mathematical programming approach for estimating efficiency, DEA is non-statistical and non-parametric. When we say it's non-statistical, we are implying that estimates are not based on any statistical distribution (eg the normal).When we refer to DEA as being non-parametric; we are referring to the fact that we do not have to assume a particular functional relationship between the inputs and outputs.

PROBLEM STATEMENT

Education is the bedrock for the sustainable development of every country. Sound education enables a population to take its destiny into its own hands. It also reduces to a large extent, what Care International (2008:10) describes as a growing "development dependency syndrome"; a phenomenon in which development initiatives from within poor communities are killed by donors through constant provision of aid and donations. Sound education helps a population to make informed decisions that promote good health, nutrition, population control etc. In fact, good education promotes all other indicators of development. More importantly, education of children facilitates a new breed of people that question archaic and unproductive socio-cultural practices that have retarded human development in most Third World Countries. Figure 2 depicts some of the benefits/ fruits of good basic education to a population.

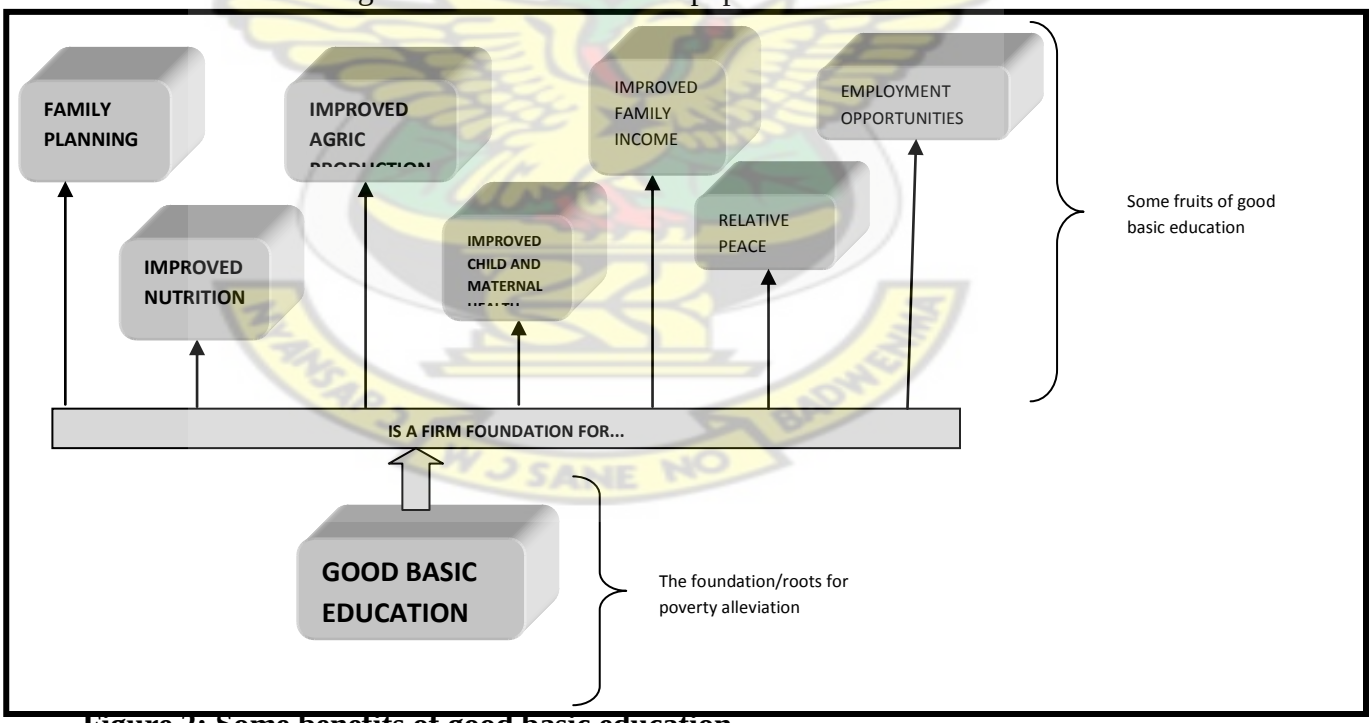

Figure 2: Some benefits of good basic education

Fig. 2 Source: Jude Bumbokuri.

For these reasons, World Vision's focus on children's education is in the right direction. It is also in tandem with the Government of Ghana's Free, Compulsory Universal Basic Education (FCUBE) programme which aims at sending all children of school going age to school. The basic level of education which ends at the Junior High School (JHS) level, according to experts, is a good basis for basic numeracy and literacy.

Having been in existence since 1979, there is the need for an in-depth research on how efficient scarce resources, given to World Vision's ADPs have been used for the betterment of the educational status of beneficiaries. This is especially against the background that World Vision aims to empower its beneficiaries to become self-sufficient in future. The research therefore aims at ascertaining the efficiencies of World Vision's educational projects at the JHS level. As this is a comparative study of the efficiency of World Vision's intervention in the area of basic education, the study will focus on a comparison between the educational interventions of four ADPs within northern Ghana. These ADPs will include Nadowli ADP, Gushegu ADP, Saboba ADP and Zabzugu ADP. Focus will be on the academic years 2009 and 2010. This is because this period allows for an objective comparative study of the level of resource efficiency employed in the four sampled ADPs under study.

OBJECTIVES OF THE STUDY

The features of Data Envelopment Analysis (DEA) will be used to measure the efficiency of educational projects. This, it is hoped, will serve as a basis for a more efficient use of donor resources for the betterment of the quality of life of its

beneficiaries. In the light of the above aim, three research objectives shall guide this study. They are;

- To assess the efficiency of World Vision Ghana's educational project performance in four Area Development Programmes using DEA focusing on the years 2009 and 2010.
- Identify the best performing ADPs to serve as a benchmark for the non-performing ADPs.
- To provide results to senior management team of World Vision Ghana to improve upon efficiency of educational projects of the four ADPs.

METHODOLOGY

Data on vehicular and human resources of the various ADPs will be used to compare their levels of efficiency. This section will look at the data collection, interpretation and analysis tools that will be employed in this comparative study. The research will therefore focus on secondary data. According to Gosling and Edwards, (1996: 43), in using secondary data, "...information required is already available and needs only to be extracted [to meet the objectives of the study]". Thus, data on world vision Education project from the four sampled ADPs in Northern Ghana as well as their respective District Offices of Ghana Education Service (GES) will be sourced. Information from the internet and the main library at KNUST will also be sourced. In terms of data interpretation and analysis, quantitative methods will largely be used as that allows for robust data gathering, interpretation, presentation and analysis. It also reduces

subjectivity to the barest minimum. In this regard, the Data Envelopment Analysis (DEA) software will be used for data input and analysis.

The DEA software will be useful in this research because it can handle multiple inputs and multiple outputs as opposed to other techniques such as ratio analysis or regression. It can also handle inputs and outputs measured in different units. DEA does not also require an assumption of a functional form relating inputs to outputs. Also, the decision making units (DMUs) are directly compared against one peer or a combination of peers. The resources from World Vision (number of staff and number of vehicles) will be considered as inputs while the outcomes of these resources (BECE pass rate and completion rate) will be considered as outputs.

JUSTIFICATION OF THE STUDY

The thesis is significant in the sense that it serves as a source of knowledge in the area of efficient use of limited resources for poverty alleviation and subsequently development. It can also be seen as a basis for further research in the areas of efficient resource management especially in educational projects of NGOs. Emphasis is on school children at the JHS level because it is the foundation that underpins the level of literacy and numeracy among a population. A porous or firm basic education invariably has rippling effects all the way up the educational ladder. It also determines a population's ability to take charge of its own destiny.

STRENGHTS AND LIMITATIONS OF THE STUDY USING DEA

STRENGTHS OF D.E.A

(1) There is no need to explicitly specify a mathematical form for the production function

(2) It is proven to be useful in uncovering relationships that remain hidden for other methodologies

(3) It is capable of handling multiple inputs and outputs

(4) It is also capable of being used with any input-output measurement

(5) The sources of efficiency can be analysed and quantified for every evaluated unit.

(6) Insight on the operational and managerial aspects of a company

LIMITATIONS OF THE STUDY

(1) Though the areas of intervention for World Vision International go beyond education (and covers other human development indicators as health, nutrition, etc.), the study only focuses on education.

(2) DEA results are sensitive to the selection of inputs and outputs

(3) DEA cannot test for the best specification

SCOPE OF WORK

This research basically aims to determine the various levels of efficient use of scarce resources within four of World Vision's ADPs in northern Ghana using features of Data

Envelopment Analysis (DEA). Its emphasis will be on basic education using 2009 and 2010 data.

ORGANISATION OF THE STUDY

This thesis shall be organised into five chapters. Chapter one shall discuss an introduction to the topic under discussion. It will entail the introduction, background, problem statement, objectives, methodology, justification, strength and limitations of DEA. It also has the scope of work and the organisation of the study. Chapter two will mainly dwell on existing literature on DEA. Chapter three will be on methodology, chapter four will be on data collection, analysis and discussion of results and chapter five will be on conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

According to Clark (2007: 105) "literature review surveys scholarly articles, books and other sources (e.g. dissertations, conference proceedings) relevant to a topic for a thesis or dissertation. Its purpose is to demonstrate that the writer has insightfully and critically surveyed relevant literature on his or her topic in order to convince an intended audience that this topic is worth addressing." Based on this definition, this section of the thesis dwells on scholarly articles using Data Envelopment analysis.

According to Portela et al. (2005) the advent of Internet banking and phone banking is changing the role of bank branches from a predominantly transaction-based one to a sales-oriented role. This paper reports on an assessment of the branches of a Portuguese bank in terms of their performance in their new roles in three different areas: Their efficiency in fostering the use of new transaction channels, their efficiency in increasing sales and their customer base, and their efficiency in generating profits. Service quality is also a major issue in service organizations like bank branches, and therefore we analyse the way this dimension of performance has been accounted for in the literature and take it into account in our empirical application. We have used Data Envelopment Analysis (DEA) for the different performance assessments. Performance comparisons on each dimension allowed us to identify benchmark bank branches and also problematic bank branches. In addition, we found positive links between operational and profit efficiency and also between transactional and operational efficiency. Service quality is positively related with operational and profit efficiency. In

order to build trust and confidence in donors of world Vision, this study aims to use the DEA tool to help in the efficient use of scarce donor resources.

Barnum et al (2007) also discussed the need for a performance measure that compares the efficiencies of subunits within a transportation organization, reflects the diversity of inputs and outputs, and is objective and consistent. The study presents a method for developing such a performance indicator, and illustrates its use with an application to the park-and-ride lots of the Chicago Transit Authority. The proposed method applies Data Envelopment Analysis supplemented by Stochastic Frontier Analysis to estimate efficiency scores for each subunit. The research demonstrates how the scores can provide objective and valid indicators of each subunit's efficiency, while accounting for key goals and values of internal and external stakeholders. The scores can be practically applied by a transit agency to identify subunit inefficiencies, and, as demonstrated by several brief case studies, this information can be used as the basis for changes that will improve both subunit and system performance.

Tubene (1997) also used data envelopment analysis to measure efficiency and productivity across nations. Multi-output and multi-input nonparametric models were used to measure efficiency (i.e., pure Technical, overall technical, and scale efficiency) and productivity (i.e., efficiency change, technical change, and productivity growth) of a sample of African, Asian, and Latin American nations. The outputs consisted of agriculture, industry, and services whereas inputs included capital, labor, and land. To bit and ordinary least squares (OLS) models were used to determine potential factors

associated with nations' efficiency and productivity. The results of this dissertation revealed that the average pure technical efficiency index for the world sample was 1.4212, 1.3333, and 1.2966 in 1983, 1992, and for the period 1983-1992 respectively whereas the average overall technical efficiency index was 1.6551, 1.4707, and 1.4710 for the same periods. While Latin America and Asia's pure and overall technical efficiency indices were generally below the world sample's average, those of Africa were above the world's average (i.e., implying poorer levels of efficiency). Overall, the results on pure and overall technical efficiency indicated that Latin America performed more efficiently than Asia and Africa. Asia ranked second. With regard to nations' productivity, the overall results showed, on average, that productivity increased slightly over the 1983-1992 time period. The Malmquist productivity index of 1.4% per year (for the world sample as a whole) was mostly due to technical advances (1%) and efficiency change (0.4%). The Tobit regression analysis indicated that food aid per capita, gross domestic saving per capita, IMF intervention per capita, inflation, infrastructure, trade balance per capita, access to safe water, and length of time since independence were associated with pure technical efficiency. Nations' overall technical efficiency, on the other hand, was influenced by the same factors except gross domestic saving per capita, and trade balance per capita. The length of time since independence was positively associated with nations' pure technical efficiency whereas the same factor negatively influenced nations' overall technical efficiency. Based on these sources of nations' inefficiency, external debt, food aid, inflation, and population growth should be discouraged whereas IMF programs, infrastructure, and access to safe water should be promoted in order to increase nations' pure technical and overall technical

efficiency. Finally, the OLS regression results revealed that inflation was the most important determinant of efficiency change. Higher inflation also decreased nations' productivity. Technical change and productivity were positively associated with trade balance per capita, and literacy. Hence, inflation should be brought under control in order to generate efficiency gains and productivity growth. Education and international trade should be promoted so as to generate technical improvements, and productivity growth.

To Alanazi et al (2010) the main objective of the paper is to examine the performance of Saudi Arabian firms as they make the transition from private ownership into public ownership. A sample of 13 Saudi initial public offers (IPOs) performance is investigated. They used data envelopment analysis (DEA) method to construct the Malmquist productivity and efficiency indices. They found that Saudi IPOs exhibited a significant decline in the productivity after the IPO as compared to the Pre-IPO level. The paper is the first to provide assessment for the clustering IPOs that occurred in the Kingdom of Saudi Arabia in recent years.

Abd El-Aleem (2005), this study suggests a model of a new set of evaluation criteria that will be used to measure the efficiency of real-world Ecommerce websites. Evaluation criteria include design, usability and performance for websites, the Data Envelopment Analysis (DEA) technique has been used to measure the websites efficiency. An efficient Web site is defined as a site that generates the most outputs, using the smallest amount of inputs. Inputs refer to measurements representing the

amount of effort required to build, maintain and perform the site. Output is amount of traffic the site generates. These outputs are measured as the average number of daily hits and the average number of daily unique visitors.

Rulindo's (2006) research attempted to investigate the efficiency of banking industry specifically in Indonesia. Three objectives were identified for this study. The first objective was to compare efficiency of big-sized banks with efficiency of medium-sized banks whilst the second objective was to compare bank efficiency based on ownership criteria and the efficiency of Islamic banks vis-a vis conventional banks. The methodology applied in this research was non parametric approach using Data Envelopment Analysis (DEA) combine with Malmquist Index. The variables identified as inputs were total deposit, personal expenses and capital expenditures while the outputs are loan and advances, capital market investment and money market investment. This research used financial data of 50 banks in Indonesia. These banks were classified into two groups: big-sized and medium-sized banks. The result showed that big-sized banks were more efficient than medium-sized banks and foreign banks were more efficient compared to other types of banks either in big-sized or medium-sized banks category. Lastly, the efficiency of Islamic banks is relatively higher than the average efficiency of conventional banks. Malmquist Index also produces almost similar results. Malmquist Total Factor Productivity (TFP) index of big-sized banks is higher than the TFP index of medium-sized banks and the TFP Index of Islamic banks is higher than TFP index of average conventional banks.

Fouad (2009) also came out with the following: The purpose of this thesis is to describe the relationship between surface water quality and land use. Water management recommendations will be divulged based upon the interaction of lake water quality and land use. The methodology developed for this research applied Data Envelopment Analysis (DEA), a performance measurement tool, to evaluate lake water quality in relation to surrounding land use. Lake performance ratings were generated by DEA software that assessed multiple variables describing surface water nutrient loads and surrounding land use. Results from this analysis revealed a significant trend between lake water quality and land use within the study area. Lakes located within a two mile radius of more naturally preserved land area typically attained higher performance ratings than lakes located within a two mile radius of less naturally preserved land area. The spatial quantity of naturally preserved land influenced lake nutrient concentrations. Also, lake performance ratings generally declined in two mile radius delineations that contained less naturally preserved land area indicating a direct relationship between natural land area and lake performance.

Wezel (2010) investigated the efficiency of domestic and foreign banks in the Central American region during 2002-07. Using two main empirical approaches, Data Envelopment Analysis and Stochastic Frontier Analysis, the paper finds that foreign banks are not necessarily more efficient than their domestic counterparts. If anything, the regional banks that were acquired by global banks in a wave of acquisitions during 2005-07 can keep up with the local institutions. The efficiency of these acquired banks,

however, is shown to have dropped during the acquisition year, recovering only slightly thereafter. Finally, it is important to account for the environment in which banks operate, as country-, sector- and firm-specific characteristics are found to have a considerable influence on bank efficiency.

Al-Eraqi et al (2007) evaluated the efficiency and performance for 22 seaports in the region of East Africa and the Middle East. The aim of their study was to compare seaports situated on the maritime trade road between the East and the West. These are considered as middle-distance ports at which goods from Europe and Far East/Australia can be exchanged and transshipped to all countries in the Middle East and East Africa. These seaports are regional coasters, and dhow trade was built on these locations, leading this part of the world to become an important trade centre. Data was collected for 6 years (2000-2005) and a non-parametric linear programming method, DEA (Data Envelopment Analysis) was applied. The ultimate goal of our study was: 1) to estimate the performance levels of the ports under consideration. This will help in proposing solutions for better performance and developing future plans. 2) to select optimum transshipment locations.

Kimsey (2009) had this to say. Attainment of greater efficiency in hospital operations has become a goal highly sought after as a result of several factors including skyrocketing costs. The possibility that the different incentives associated with ownership type might affect efficiency has been covered thoroughly in the literature. There are numerous

studies comparing for-profitto not-for-profit hospitals or public to private hospitals. Analysis of federal ownership, however, has been less studied. In particular, comparisons involving military hospitals are non-existent, attributed to data availability and an assumption that military hospitals are too different from civilian facilities. The dissertation employed a cross-sectional Stochastic Frontier Analysis ("SFA") of 2006 data to compare the technical efficiency of military, for-profit, not-for-profit, and other government hospitals, controlling for differences in patients, scope of work, physician hospital working arrangements, and other structural characteristics. Four model specifications are examined, varying the method of accounting for heterogeneity of case mix. One of the specifications uses a distance function technique to allow for specific inclusion of multiple outputs, namely inpatient and outpatient workload. Results obtained using SFA are validated using Data Envelopment Analysis ("DEA") and compared with results produced through simple ratio analysis. Estimates of overall technical efficiency ranged from 76% to 80%. The analysis found no significant correlation between ownership category and technical efficiency. Factors found to be significantly correlated with greater technical efficiency include younger average patient age, more female patients, percentage of surgical inpatient work, percentage of circulatory system-based work, accreditation, and having all credentialed physicians (i.e. no physician employees). Pooled-vs.-partitioned analysis showed that military hospitals are indeed different, but not enough to render comparisons meaningless. Data Envelopment Analysis produced comparable individual hospital efficiency scores (correlations of approximately 0.6 between like specifications using SFA and DEA) and comparable average efficiency

(~87%). Ratio analysis results were sensitive to the specific ratio analyzed. This dissertation adds to the body of literature on the relationship between ownership and hospital technical efficiency. It is the first comparison of military and civilian hospital technical efficiency.

Javed et al (2010) conducted a study in the Department of Agricultural Economics, University of Agriculture, Faisalabad, Pakistan during the year 2007 to estimate technical efficiency and identify the determinants of technical inefficiency of rice-wheat farming system in Punjab. For this purpose a non-parametric data envelopment analysis (DEA) technique was applied. Tobit regression model was estimated to investigate determinants of technical inefficiency of the system. The results revealed that mean technical efficiency of the system was 0.83, with minimum level of 0.317 and maximum of 1. This indicated the existence of substantial technical inefficiency in rice-wheat system in Punjab. The study further revealed that if sample farms in rice-wheat system operated at full efficiency level these could reduce their input use by 17 percent without any reduction in level of output and with existing technology. Results of the Tobit regression model showed that years of schooling, number of contacts with extension agents and access to credit variables had negative impact while farm size, age of farm's operator and farm to market distance had positive impact on technical inefficiencies of rice-wheat system in Punjab. Javed et al (2010) suggested that government should focus on attracting young and educated people in farming by providing incentives in the form of soft loans.

Avkiran (2001) contended that performance indicators in the public sector have often been criticised for being inadequate and not conducive to analysing efficiency. The main objective of this study was to use data envelopment analysis (DEA) to examine the relative efficiency of Australian universities. Three performance models were developed, namely, overall performance, performance on delivery of educational services, and performance on fee-paying enrolments. The findings based on 1995 data show that the university sector was performing well on technical and scale efficiency but there was room for improving performance on fee-paying enrolments. There were also small slacks in input utilisation. More universities were operating at decreasing returns to scale, indicating a potential to downsize. DEA helps in identifying the reference sets for inefficient institutions and objectively determines productivity improvements. As such, it can be a valuable benchmarking tool for educational administrators and assist in more efficient allocation of scarce resources. In the absence of market mechanisms to price educational outputs, which renders traditional production or cost functions inappropriate, universities are particularly obliged to seek alternative efficiency analysis methods such as DEA.

According to Piner (2006) the Department of Defense is facing medical expenses that are growing at an unprecedented rate. The top leadership is looking for ways to reduce costs and improve efficiency while still providing world class medical care for its beneficiaries. One option is to implement a relatively new tool called Data Envelopment Analysis (DEA). This tool uses linear programming to identify efficient entities, called

decision making units (DMU), relative to the other entities in the set. In the past, DEA studies used military hospitals as DMUs. This study is different in that it uses clinics within hospitals as DMUs. The rationale behind this is that administrators have difficulty using data that tells them in general terms that they have too many people or are spending too much money. What they need is a tool that tells them where there are too many people or where they are spending too much money. A hospital is made up of clinics so it is intuitive to begin by improving the efficiency of the clinics which in turn will improve the efficiency of the whole hospital.

Sheth et al (2003) stated that, in most situations optimal achievement of multiple goals is rarely possible for crisp mathematical programming techniques. In such cases, a compromise achievement of goals that leads to a satisfying solution rather than an optimal solution bears more relevance. The present research introduces a Fuzzy Goal Data Envelopment Analysis (Fuzzy GoDEA) framework to measure and evaluate the goals of efficiency and effectiveness in a fuzzy environment. Fuzzy GoDEA accommodates crisp input and output data but allows imprecise specification of the aspiration levels for the efficiency and effectiveness goals. A membership function is defined for each fuzzy constraint associated with the efficiency and effectiveness goals and represents the degree of achievement of that constraint. Further, the Fuzzy GoDEA framework is extended into several variations that (i) allow the assignment of relative importance to the goals of efficiency and effectiveness and (ii) model scenarios where one of the goals of efficiency and effectiveness is crisp and the other fuzzy. The Fuzzy

GoDEA framework is implemented for a newspaper preprint insertion process (NPIP).

Kumar (2007), the Data Envelopment Analysis (DEA) model is used to work out technical efficiency of Information and Communication Technology (ICT) Industry in host of countries which are front runners as far as ICT is concerned. India lags behind the most as far as ICT (not IT) is concerned. However, information and Communication technology industry has brought revolution in India because it has reduced intermediation in business and society, provided solutions across sectors and is increasingly becoming an important tool for national development. DEA is also applied to benchmark the performance of the 92 Indian Software Companies for 2005- 2006. The impact of various determinants on technical efficiency of the Indian Software companies is worked out using tobit regression. The impact of the explanatory factors on net exports of 92 software firms in 2005- 06 is also worked out using simple regression exercise. The study also works out technical efficiency of 36 telecommunication firms in India and examines the determinants for new technology adoption by such industries. The study uses a Malmquist index to estimate total factor productivity changes decomposed into efficiency change (catching up to the frontier technology) and technical change (movement of the frontier) for the common software firms existing between 1996 and 2006.

According to Travis (2010), in the current economic climate, many companies are facing pressures to operate more efficiently resulting in frequent mergers, acquisitions, and

reorganizations. This often necessitates a change in various network structures within these organizations, which leads to the guiding question of this study. How does an organization efficiently and effectively transition its network structures while making use of multiple performance measures? This dissertation seeks to develop models and algorithms, based on Data Envelopment Analysis (DEA), to analyze perturbations in real-world network topologies. The first part of this dissertation shows the historical development of DEA with an introduction of notation and extensions. The next chapter is a detailed study of US airport inefficiency, which answers the question: Is there a difference in the efficiency of hub and non-hub airports in the United States? After decomposing the efficiency into scale efficiency, mixed efficiency and pure technical efficiency, the Wilcoxon Rank Sum test is able to show that there are differences between hub and non-hub airports. The fourth section of the dissertation develops a theoretical model, the Inverse Range-based Directional Distance model (INVRDD-DEA), to address the presence of reverse quantities in DEA and yield shortest path projections. This model leads to the Fully Comprehensive RDD-DEA model that takes into account all sources of inefficiency. This model is then used to illustrate all sources of inefficiency in a greenhouse gas example. The final contribution of the dissertation is an exploration into the evolution of the operations research approach to the field of network science. The concept of re-engineering of networks, defined as the ability to optimize perturbations to existing networks based on several performance metrics, is used as a methodological model for typical types of changes that exist in cooperate networks. The critical factors for building an algorithm for modifying network topologies

are identified and used to design a procedure for making changes in networks. Finally, an example of an ERP implementation is given to show the benefits of using DEA to make changes to existing network topologies.

Iervolino's (2002) study introduced a prototype managerial tool for measuring and managing the efficiency of business to consumer (B to C) Web sites. By defining each Web site as a separate Decision Making Unit (DMU), this tool is able to utilize Data Envelopment Analysis (DEA) to determine which sites are the most efficient and provide guidelines to improve the efficiency of the sub-optimal sites. Within the context of this study, an efficient Web site is defined as a site that generates the most output, using the smallest amount of inputs. Inputs refer to measurements representing the amount of effort required to build and maintain the site. For the purposes of this study, they include metrics which track the amount of Web site content, the frequency of content update and the complexity of the content and its arrangement. This study defines Web site output as amount of traffic the site generates. These outputs are measured as the average number of daily hits and the average number of daily peak hits the site generates. This data is then adapted and incorporated into the DEA-based model to measure efficiency, and provide recommendations, for comparable B to C Web sites. Data is collected from 12 Web sites, using two different Web site analysis software tools and services. Only static e-commerce Web sites which contain catalogs, which are created using exclusively static content, are included in this test. In order to limit scope, this study uses three separate Web site characteristics to select only simpler Web sites, more typical of small business.

Firstly, the study examines only sites containing catalogs comprised of exclusively static content. Secondly, it considers only those sites that have less than 250 hypertext markup language (HTML) pages. And thirdly, it uses only sites whose traffic is measured by a single objective third party Web-tracking service. The resulting DEA model then generates relative efficiency scores and related recommendations for improvement for each Web site. The results are interpreted against those of typical Web site efficiency measurement methods and appropriate generally accepted Web design best practice recommendations.

For Watson (2003), institutional and individual investors have always been interested in identifying those mutual funds that appear to outperform the market more often than not. Identification of such funds is not difficult as a simple comparison against the market index allows individual fund performance to be evaluated on an absolute basis. However, this approach is insufficient for investors to make a comparison between funds with different return and risk levels. Entrenched in finance literature is the Sharpe measure and co-efficient of variation, techniques that utilize both the standard deviation (a measure of risk) and expected return (a measure of return). This thesis proposes using a new methodology, Data Envelopment Analysis, to evaluate mutual funds on a relative basis. Data Envelopment Analysis (DEA) is widely used to analyze the relative efficiencies of decision-making units (DMUs) that are similar in nature. There are two important versions of DEA, namely, Deterministic Data Envelopment Analysis (DDEA) developed to consider deterministic input and output variables, and Stochastic Data

Envelopment Analysis (SDEA) used extensively when input or output variables are random in nature. This thesis applies a simulation approach to SDEA based on EXCEL/@RISK, which provides a variety of informative statistical measures about the stochastic properties of the efficiency figure. The approach is illustrated by analyzing the relative performance of the largest United States equity mutual funds towards the end of the 20th century using historical data to identify significantly efficient and inefficient funds. The model is validated using an extensive window analysis where the results obtained by the SDEA model are compared with the traditional mean-variance approaches preferred in the past. This introduces to the portfolio performance evaluation literature a new tool for evaluating relative (as opposed to absolute) fund performance.

Liu et al (2004) also, in their study, evaluated relative managerial efficiencies of Taiwan's 38 upgraded technical institutes, using the Data Envelopment Analysis approach, including both relative efficiency and cross-period efficiency variation analyses. Analyses included the influences of school type, geographical location, and school size on school managerial efficiency performances. The analysis results indicated the following two main points: first, there is a significant correlation between school types and relative efficiency. Since ten out of twelve relatively efficient schools are private, this indicates that private schools achieve better managerial efficiency, even though they have less resources; second, there is a significant correlation between school size and relative efficiency. Schools which have more than 201 classes achieved the best managerial efficiency in economic scale. Because there is no significant correlation

between geographical location and managerial efficiency, this indicates that the geographical location will not have a significant effect and in managerial efficiency. According to the analysis results of cross-period efficiency variation, the technical changes are slightly increasing in Taiwan's technical institutes which have been upgraded from junior colleges. This means there is an improvement of overall technical level and a small scale. The improvement of efficiency change is higher than the technical change; indicating that there is a recession of school production technique. By the analysis results of managerial matrix, composed of relative efficiency and technical change; most of those technical schools have development potential. The leading schools are: S1, S2, S4, S7, S9, S10, and S11. The under-developed schools are: S31, S32, S33, S34, S35, S36, S37, S38. These underdeveloped schools need to formulate more thoughtful short-term plans and make their management more efficient. This study employed Data Envelopment Analysis (DEA) to examine the relative managerial efficiency of 38 Taiwanese technical institutes, which had been upgraded from junior colleges by 1998, and evaluated the managerial efficiency variations for each individual institute between 1995 and 1998. By integrating the results of both relative managerial efficiency analysis and managerial efficiency variation analysis, a management decision-making matrix was prepared, which pointed out indices and the innovative direction of the improvement of site management and resource application. Matrices of this type can help site management to design more appropriate improvement strategies and to achieve greater improvements. They can also help educational authority's officials to present a more appropriate evaluation system, which will provide accurate feedback information,

making a professional school evaluation and guidance more effective.

Karlson et al (2004) used data envelopment analysis to evaluate the efficiency of selected Illinois high schools. Sixty-one Illinois high schools were selected based on common structural characteristics. Data for school years 1996-1997 to 2000-2001 from the Illinois High School Report Card and the National Center for Education Statistics were analyzed. Discretionary and non-discretionary input variables were considered. The impact of these input variables on school outcomes was systematically analyzed. Data envelopment analysis simultaneously evaluates multiple inputs and multiple outputs to establish a convex hull efficiency frontier that envelops all data points for the schools. Those falling inside the convex hull are considered inefficient. The variable returns to scale model with four non-discretionary variables was selected to analyze the school data. Results showed that in general the high schools in the sample were relatively efficient given the environmental conditions under which they operated. However, some of their outputs may not be ideal, representing further room for improvement. For the schools that were deemed inefficient, closer scrutiny showed that they would have been able to produce the same level of outputs using lower combinations of inputs. Window analysis identified the schools that showed relatively constant efficiency throughout the study period, those whose efficiency dropped after the first year and those whose efficiency dropped at the last year. These results have policy implications. Those officials responsible for allocating resources may want to take a closer look at the schools that were deemed inefficient and require them to reexamine the management of their resources. At the

same time, those schools that are already performing efficiently given their resources should also be examined. Some of the schools that were deemed efficient but are not performing up to par could potentially raise the level of their outputs if they could be allocated more resources. Data envelopment analysis will be useful for policy makers and school officials when making decisions in the allocation of state resources and demanding accountability for the use of those resources. For each school, specific outputs or inputs can be examined to determine which inputs need adjustments or which outputs could still be raised.

Agha et al (2011) came out with these findings. In this age of knowledge economy, universities play an important role in the development of a country. As government subsidies to universities have been decreasing, more efficient use of resources becomes important for university administrators. This study evaluates the relative technical efficiencies of academic departments at the Islamic University in Gaza (IUG) during the years 2004-2006. This study applies Data Envelopment Analysis (DEA) to assess the relative technical efficiency of the academic departments. The inputs are operating expenses, credit hours and training resources, while the outputs are number of graduates, promotions and public service activities. The potential improvements and super efficiency are computed for inefficient and efficient departments respectively. Further, multiple linear -regression is used to develop a relationship between super efficiency and input and output variables. Results show that the average efficiency score is 68.5% and that there are 10 efficient departments out of the 30 studied. It is noted that departments

in the faculty of science, engineering and information technology have to greatly reduce their laboratory expenses. The department of economics and finance was found to have the highest super efficiency score among the efficient departments.

Giannoccaro et al (2011) argued that water management is subject to conflicting economic and environmental objectives and policy makers require a clear overview of the various outcomes of different water management options. In the present paper we propose a non-parametric benchmarking technique based on Data Envelopment Analysis (DEA), specifically developed to assess the relative efficiency of alternative water pricing policies. The result of the analysis is a ranking of pricing policies, aimed at supporting decision making process. An empirical study case was carried out in Southern Italy (Apulia region), where irrigation is an important factor of strategic relevance for policy makers. Six different pricing methods were compared. According to the findings, the alternative pricing policies perform similarly in terms of technical efficiency. However, the results show that the alternatives rank differently for the technical efficiency and the ecological efficiency indicator. The ecological efficiency shows up to 10% of inefficiency. We conclude that efficiency may be a convenient method for ranking policy hypotheses in the case of absence of information on stated preferences on some outcomes, as well as some negative environmental impacts.

Kazan et al (2011) in their study measured the performance of software development teams with the data envelopment analysis. In the measurement process, multiple input

and output from research and development, intellectual capital and firm infrastructure projects as intangible assets with many different aspects were taken into consideration and performance was evaluated. The data were obtained from an application development center, year 2009 human resources database. For the evaluation, year 2009 Application Development Annual Report, demands met with services and customer satisfaction survey results were used. Administrative staff, customer satisfaction, actualized demand, programming errors and omissions were determined in relation to team costs and important conclusions were reached.

Tsakas (2011) also said that the control of healthcare costs as well as the means for this achievement is a multifaceted problem for governments all over the world. The aim of this work is to determine the areas of activity of 16 Greek Public Hospital Units (H.U.), which present problems regarding their performance and suggest sufficient solutions. The method used for this study was quantitative analysis methods and especially the application of Data Envelopment Analysis (D.E.A.) in the 16 H.U. According to the results, information was provided to their managers, concerning: (i) the assessment of the sources of management pathogenesis per H.U., (ii) the essential information about the mapping out of the best utilization of financial resources by H.U. administrations and (iii) the evaluation criteria of H.U. administrations. The derived information provided basic guidelines about the creation of an appropriate policy plan per H.U., which should be applied by their administrations in combination with a set of measures that need to be undertaken in order to promote efficiency.

According to Hasanov (2011) Water scarcity and land degradation increases led to a sharp rise in input resources costs. These developments make it increasingly difficult for agricultural farms to produce according to the demand for food and other commodities, especially owing a rapid population growth. The study also aimed to focus on scarce resource use in the agricultural production of the Zarafshan valley by means of the efficiency analysis. A DEA model is estimated to investigate the farm level efficiency levels with respect to the use of the limited resources available to the farmers. By the application of linear programming methods a best practice frontier is estimated, classifying farms on the frontier as efficient and others as inefficient with respect to different scales. Technical and allocative efficiencies are calculated relative to the frontier. Results shows input resources are not used efficiently and a great majority of farms could effectively reduce considerable amounts of input use by still producing the same output.

For Banaeian et al (2011). Investigation of strawberry greenhouses showed a big variation of data and high mean benefit to cost ratio (1.74), so the proper potential was seen for improvement of economic efficiency and management in strawberry greenhouses and detailed study was seriously required. In this study, Data Envelopment Analysis (DEA) technique was applied to investigate the degree of technical and scale efficiency of greenhouse strawberries of Iran, also to compare and optimize the performance of each greenhouse. Based on the amount of four important inputs: human labor (h/ha), fertilizers (kg/ha), capital ($/ha) and other expenses ($/ha), and gross return

of strawberry ($/ha) as output. Mean technical efficiency was 0.73, indicating that there is ample potential for more efficient and sustainable input utilization in production and 27% of overall resources could be saved. The majority of the scale-inefficient greenhouses are operating under increasing returns to scale; efficiency analysis theory suggests that they are obviously small greenhouses that need to increase their sizes in order to achieve cost savings. Ranking of productive efficiencies based on the four mentioned inputs is also shown to differ significantly from that based on a single resource (labor).

CHAPTER THREE

INTRODUCTION

This chapter outlines the Data Envelopment Analysis (DEA) approach used in measuring efficiency.

METHODOLOGY

Data Envelopment Analysis (DEA) has proven to be a powerful tool for the analysis of the magnitude and cause of inefficiency. It is now widely applied to performance analysis in such diverse fields. DEA uses linear programming to establish an 'efficiency frontier' from the most efficient utilities from a set of data. A boundary is created by linearly linking the observed performance of the best performing companies in the sample, and is determined by the relationship between their inputs and outputs (Figure 3). Utilities that form the efficiency frontier use the minimum quantity of inputs to produce the same quantity of outputs as other, similar utilities.

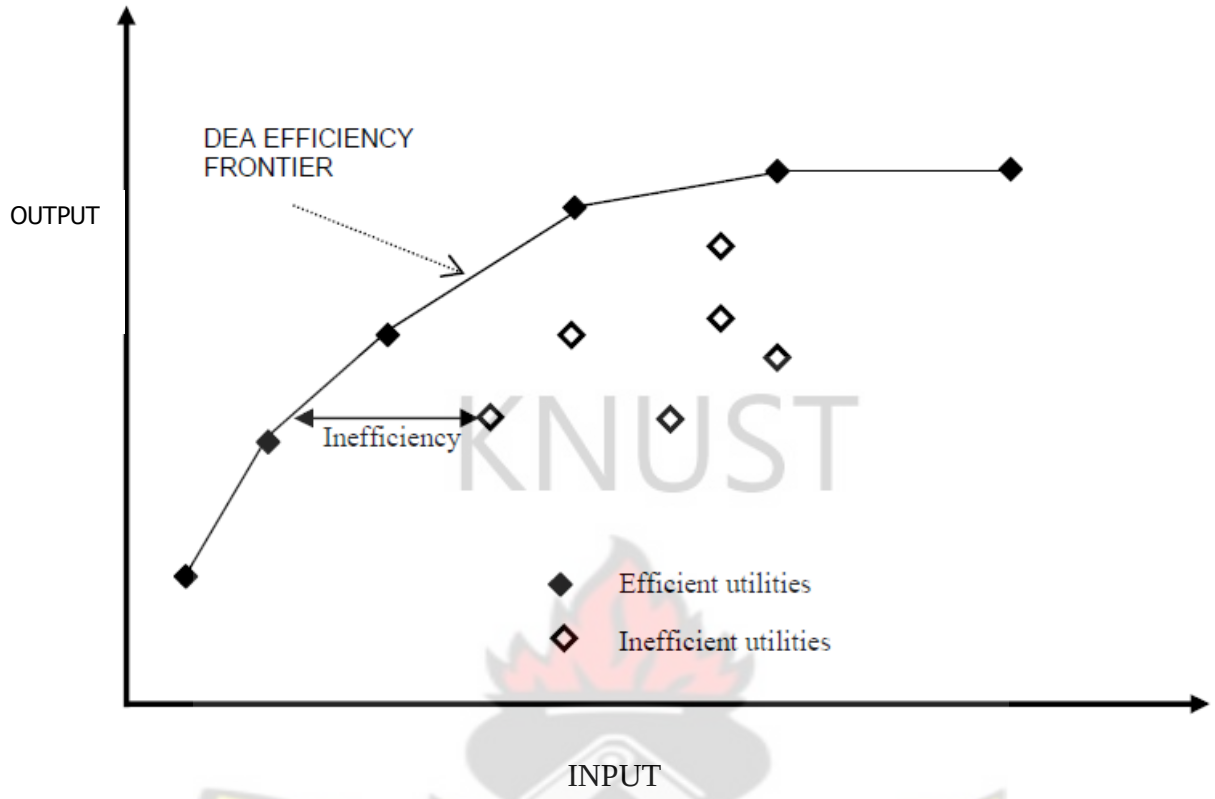

Figure 3: DEA efficiency frontier diagram

Data Envelopment Analysis (DEA) is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA applications have used DMUs of various forms to evaluate the performance of entities, such as hospitals, US Air Force wings, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc. Because it requires very few assumptions, DEA has also opened up possibilities for use in cases

which have been resistant to other approaches because of the complex (often unknown) nature of the relations between the multiple inputs and multiple outputs involved in DMUs.

To allow for applications to a wide variety of activities, we use the term Decision Making Unit (=DMU) to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs. These evaluations can involve governmental agencies and not-for-profit organizations as well as business firms. The evaluation can also be directed to educational institutions and hospitals as well as police forces (or subdivision thereof) or army units for which comparative evaluations of their performance are to be made.

Using DEA model, researchers are required to formulate the problem into mathematical expression. The mathematical formulation of DEA technique consists in the solution of a set of linear programming models (Charnes, Cooper, and Rhodes, 1978) aimed at maximizing the efficiency of decision making units (DMUs).

Inputs are elemental factors or resources (e.g. labour, capital, human resource) that significantly affect the consumption of available resources used in an institution.

Outputs are factors that trigger the quantity of outcomes obtained from available resources (eg service and production) being processed in an institution.

DEA is a procedure that has been developed to measure relative efficiency in situations where there are multiple inputs and outputs. It is a procedure designed to evaluate relative efficiency of public sectors Decision Making Units (DMUs) performing similar missions for which actual measures of inputs and outputs are available.

The relevant inputs and outputs factors and the numerical measures for the factors identified are used to formulate the linear programming model. Using input and output factors in Table 1 simple DEA models are formulated. To see the structure of a typical DEA model more clearly, consider the model illustrated in Table 1, which has m DMUs, each with n input factors X_1, X_2, $X_{3\ldots}$ Xn and outputs factors $Y_{1,}$ $Y_{2,}$ $Y_{3\ldots}Y_p$

Table 1: Structure of typical DEA model

DMUs	Input factors				Output factors			
	X_1	X_2	X_3	.....X_n	Y_1	Y_2	Y_3	.....Y_P
1	$X_{1\,1}$	$X_{2\,1}$	$X_{3\,1}$	$X_{n\,1}$	$Y_{1\,1}$	$Y_{2\,1}$	$Y_{3\,1}$	$Y_{P\,1}$
2	$X_{1\,2}$	$X_{2\,2}$	$X_{3\,2}$	.	$Y_{1\,2}$	$Y_{2\,2}$	$Y_{3\,2}$	.
3	$X_{1\,3}$	$X_{2\,3}$	$X_{3\,3}$	.	$Y_{1\,3}$	$Y_{2\,3}$	$Y_{3\,3}$	.
4	X_{14}	$X_{2\,4}$	$X_{3\,4}$	.	$Y_{1\,4}$	$Y_{2\,4}$	$Y_{3\,4}$	.
5	$X_{1\,5}$	$X_{2\,5}$	$X_{3\,5}$	.	$Y_{1\,5}$	$Y_{2\,5}$	$Y_{3\,5}$	.
.	.	.	.		.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
M	$X_{1\,m}$	$X_{2\,m}$	$X_{3\,m}$	$X_{n\,m}$	$Y_{1\,m}$	$Y_{2\,m}$	$Y_{3\,m}$	$Y_{p\ m}$

Let

$X_{1\,1}$…...$X_{n\,m}$ represent input factors for DMU1…..DMUm

$Y_{1\,1}$…. $Y_{P\,m}$ represent output factors for DMU1…..DMUm

X_1…….X_n represent input factors 1. ..n.

Y_1…….Y_P represent output factors 1…p.

Also let

μ_1……μ_n represent output weights.

V_1….V_p represent input weights.

Now consider the efficiency of DMU1:

Using the CCR -Ratio Model,

Efficiency=$\frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs}$

Efficiency of DMU1=$\frac{\text{outputs}}{\text{inputs}}=\frac{\mu_1 Y_{1\,1}+\mu_2 Y_{2\,1}+\cdots+\mu_p Y_{p\,1}}{V_1 X_{1\,1}+V_2 X_{2\,1}+\cdots+V_n X_{n\,1}}$

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Efficiency of DMUm =$\frac{\text{outputs}}{\text{inputs}}=\frac{\mu_1 Y_{1\,m}+\mu_2 Y_{2\,m}+\cdots+\mu_p Y_{p\,m}}{V_1 X_{1\,m}+V_2 X_{2\,m}+\cdots+V_n X_{n\,m}}$

∴ Efficiency of DMUm = $\frac{\sum_{i=1}^{p}\mu_i Y_{i\,m}}{\sum_{r=1}^{n} V_r X_{r\,m}}$

Where

i=1 to p

r=1 to n

μ_i=weight assigned to output i

V_r=weight assigned to input r

$Y_{i\,m}$=value of output i for DMU m

$X_{r\,m}$=value of input r for DMU m

What is now sought is the set of weighting factors μ and V which maximise the efficiency

measure, subject to constraints on the efficiency of the m DMUs. This lead to the Non Linear Program.

$$\frac{\sum_{i=1}^{p}\mu_i Y_{i\,m}}{\sum_{r=1}^{n}V_r X_{r\,m}} \leq 1,$$

$\mu_i \geq 0$

$V_r \geq 0$

$V_r X_{r\,m} > 0$

This can be linearised by applying a normality constraint on the weighted inputs and arranging the other constraints. The output can be maximised after constraining the weighted inputs to unity. Therefore,

Maximize $\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm}$

Subject to $V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm} = 1$

For the constraint on DMUm

$$\frac{\mu_1 Y_{1m} + \mu_2 Y_{2m} + \cdots + \mu_p Y_{pm}}{V_1 X_{1m} + V_2 X_{2m} + \cdots + V_n X_{nm}} \leq 1$$

$$\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm} \leq V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm}$$

$$(V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm}) - (\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm}) \geq 0$$

$$\mu, V \geq 0$$

The above formulation can be used to calculate efficiency involving combination of various inputs and outputs.

The relative efficiency score of a DMU will depend upon the choice of weight μ and V. In the traditional basic efficiency measure, the weights are assumed to be uniform across the input and output variables. DEA, however select the weight that maximizes each DMU's relative efficiency score under the condition that no weight is negative, and that

resulting efficiency ratio must not exceed one. For each DMU, DEA will choose those weights that would maximize the relative efficiency score in relation to other DMUs.

CHAPTER FOUR

INTRODUCTION

This chapter describes the data used, how DEA is applied to measure the efficiency of educational projects in four Area Development Programmes (ADPs) of World Vision Ghana. We also analysed the factors that may be associated with the efficiency score.

After defining the inputs and outputs from our source data, the excel solver software was used to run CCR model (refer to appendix A for the programme solution).

DESCRIPTION OF DATA

The data used in this research is collected from four ADPs of World Vision and four district education offices. The data covers from 2009 academic year to 2010 academic year.

DESCRIPTION OF INPUTS AND OUTPUTS

In using DEA first of all you look out for inputs and out puts of the system. This will enable us to measure the efficiency of our educational projects in the ADP.

The two inputs to be used will include number of staff for an ADP and numbers of vehicles per an ADP. The two outputs also include completion rate of students at JHS level and BECE pass rate.

The decision making units (DMUs) chosen are Zabzugu ADP, Saboba ADP, Gushegu ADP and Nadowli ADP.

EFFICIENCY MODELLING

The basic DEA model for measuring the efficiency of educational projects can be formulated as follows:

Maximise $\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm}$

Subject to $V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm} = 1$

For the constraint on DMUm

$$\frac{\sum_{i=1}^{p} \mu_i Y_{im}}{\sum_{r=1}^{n} V_r X_{rm}} \leq 1$$

$\mu_i \geq 0$

$V_r \geq 0$

$V_r X_{rm} > 0$

$$\frac{\mu_1 Y_{1m} + \mu_2 Y_{2m} + \cdots + \mu_p Y_{pm}}{V_1 X_{1m} + V_2 X_{2m} + \cdots + V_n X_{nm}} \leq 1$$

$$\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm} \leq V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm}$$

$$(V_1 X_{1m} + V_2 X_{2m} + \ldots + V_n X_{nm}) - (\mu_1 Y_{1m} + \mu_2 Y_{2m} + \ldots + \mu_p Y_{pm}) \geq 0$$

Where

i=1 to p

r=1 to n

μ_i=weight assigned to output i

V_r=weight assigned to input r

Y_{im}=value of output i for DMU m

X_{rm}=value of input r for DMU m

The excel solver software was used to solve the formulated Linear programming problems (refer to appendix for programme solution).

DATA COLLECTED

Table 2 shows data obtained for 2009 academic year

DMU	INPUT Number of staff	INPUT 2 Number of vehicles	OUTPUT 1 Completion rate at JHS (in percentages)	OUTPUT 2 BECE Pass rate (in percentages)
ZABZUGU ADP	4	2	43	60.5
SABOBA ADP	3	2	83	34.9
GUSHEGU ADP	7	3	91.4	36.05
NADOWLI ADP	6	2	65	55.7

Table 3 shows data obtained for 2010 academic year

DMU	INPUT 1 Number of staff	INPUT 2 Number of vehicles	OUTPUT 1 Completion rate at JHS (%)	OUTPUT 2 BECE Pass rate (%)
ZABZUGU ADP	5	2	40.1	92.1
SABOBA ADP	6	3	85	24.2
GUSHEGU ADP	6	3	91.4	65.35
NADOWLI ADP	6	2	61	62.5

The linear programming formulated out of the data for 2009 and 2010 are as follows:

For 2009

Max: Zabzugu ADP = $43u_1+60.5u_2$

Subject to: $4v_1+2v_2=1$

$43u_1+ 60.5u_2 \leq 4v_1+2v_2$

$83u_1+ 34.9u_2 \leq 3v_2+2v_2$

$91.4u_1+ 36.05u_2 \leq 7v_1+3v_2$

$55.7u_1+ 65u_2 \leq 6v_1+ 2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max: Saboba ADP = $83u_1+ 34.9u_2$

Subject to: $3v_2+2v_2 =1$

$43u_1+ 60.5u_2 \leq 4v_1+2v_2$

$83u_1+ 34.9u_2 \leq 3v_2+2v_2$

$91.4u_1+ 36.05u_2 \leq 7v_1+3v_2$

$55.7u_1+ 65u_2 \leq 6v_1+ 2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max: Gushegu ADP=$91.4u_1+ 36.05u_2$

Subject to: $7v_1+3v_2 =1$

$43u_1+ 60.5u_2 \leq 4v_1+2v_2$

$83u_1 + 34.9u_2 \leq 3v_2 + 2v_2$

$91.4u_1 + 36.05u_2 \leq 7v_1 + 3v_2$

$55.7u_1 + 65u_2 \leq 6v_1 + 2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max Nadowli ADP = $55.7u_1 + 65u_2$

Subject to: $6v_1 + 2v_2 = 1$

$43u_1 + 60.5u_2 \leq 4v_1 + 2v_2$

$83u_1 + 34.9u_2 \leq 3v_2 + 2v_2$

$91.4u_1 + 36.05u_2 \leq 7v_1 + 3v_2$

$55.7u_1 + 65u_2 \leq 6v_1 + 2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

For 2010

Max: Zabzugu ADP=$40.1u_1 + 92.1u_2$

Subject to: $5v_1 + 2v_2 = 1$

$40.1u_1 + 92.1u_2 \leq 5v_1 + 2v_2$

$85u_1 + 24.2u_2 \leq 6v_1 + 3v_2$

$91.4u_1 + 65.35u_2 \leq 6v_1 + 3v_2$

$61u_1 + 62.5u_2 \leq 6v_1 + 2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max: Saboba ADP=$85u_1+24.2u_2$

Subject to: $6v_1+3v_2=1$

$40.1u_1+92.1u_2 \leq 5v_1+2v_2$

$85u_1+24.2u_2 \leq 6v_1+3v_2$

$91.4u_1+65.35u_2 \leq 6v_1+3v_2$

$61u_1+62.5u_2 \leq 6v_1+2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max: Gushegu ADP=$91.4u_1+65.35u_2$

Subject to: $6v_1+3v_2 = 1$

$40.1u_1+92.1u_2 \leq 5v_1+2v_2$

$85u_1+24.2u_2 \leq 6v_1+3v_2$

$91.4u_1+65.35u_2 \leq 6v_1+3v_2$

$61u_1+62.5u_2 \leq 6v_1+2v_2$

$u_1 \geq 0;\ u_2 \geq 0;\ v_1 \geq 0;\ v_2 \geq 0$

Max: Nadowli ADP=$61u_1+62.5u_2$

Subject to: $6v_1+2v_2=1$

$40.1u_1+92.1u_2 \leq 5v_1+2v_2$

$85u_1+24.2u_2 \leq 6v_1+3v_2$

$91.4u_1+65.35u_2 \leq 6v_1+3v_2$

$61u_1+62.5u_2 \leq 6v_1+2v_2$

$u_1 \geq 0;\ u_2 \geq 0; v_1 \geq 0;\ v_2 \geq 0$

The efficiency scores of the four ADPs obtained from DEA using the CCR model were under the following conditions:

1. All data and all weights are positive
2. Efficiency scores must lie between zero and unity
3. The same weights for the target ADP are applied to all ADPs.

Table 4 shows the results providing the relative efficiency of each ADP for each year.

DMU	2009 Relative Efficiency	2010 Relative Efficiency	% change in Relative Efficiency(2009-2010)
Zabzugu ADP	1.0000	1.0000	0.0000%
Saboba ADP	1.0000	0.7024	-29.7600%
Gushegu ADP	0.6643	1.0000	50.5344%
Nadowli ADP	1.0000	0.7849	-21.5100%

The efficiency score of the ADPs for 2009 and 2010 ranges from 0.6643 to 1.The maximum efficiency score is 1.The minimum efficiency score is 0.6643.The average efficiency of all ADPs is 0.9161 and 0.8718 for the year 2009 and 2010 respectively.

In the year 2009, Zabzugu ADP,Soboba ADP and Nadowli ADP performed better than Gushegu ADP because each of them has an efficiency score 0f 1 and that of Gushegu ADP is 0.6643.Gushegu ADP may consider Nadowli ADP or Zubzugu ADP or Soboba ADP as a benchmark for improving its efficiency for the year 2009.

Saboba ADP and Nadowli ADP are inefficient while Zabzugu ADP and Gushegu ADP are effiencient in the year 2010.Nadowli ADP and Soboba ADP may use Zabzugu ADP or Gushegu ADP as benchmark for improving their efficiency performance for the year 2010.

Considering these two years (2009 and 2010) Saboba ADP and Nadowli ADP have decreased in their efficiency scores by 29.76% and 21.51% respectively.Gushegu ADP has improved significantly in its efficiency score by 50.5344%.

ANSWER REPORT ON ZABZUGU ADP AS THE TARGET DMU-2009

Table 5: Target Cell (Max)

Cell	Name	Original Value	Final value
G6	Zabzugu ADP Weighted output	103.5	1

Table 6: Adjustable Cells

Cell	Name	Original Value	Final Value
C11	Completion rate	1	0.006527567
D11	BECE pass rate	1	0.011889498
E11	Number of staff	1	0.043268446
F11	Number of vehicles	1	0.413463108

Considering the Tables 5 and 6 the optimal value solution to linear programming has the value one (1).The best input weights are given as 0.413463108 for number of vehicles and 0.043268446 for number of staff. The best output weights are also 0.011889498 BECE pass rate and 0.006527567 completion rate.

The ratio of the input weights gives= $\frac{0.413463108}{0.043268446}$=9.5558.To maximize efficiency number of vehicles should have weight 9.5558 times that of number of staff. It therefore means that when you reduce the number of vehicles it will have a bigger effect on efficiency than reducing the number of staff.

IMPROVEMENT FOR GUSHEGU ADP -2009

The calculation of relative efficiency has one of its assumptions as if ADP A is termed efficient by utilisation its input(s) to obtain some level of output(s), then other ADPs should be able to perform the same if they are to operate efficiently.

Gushegu ADP is inefficient. To improve the performance of Gushegu ADP we must set one of the ADPs that are efficient as a benchmark. Thus input target is equal to actual input for inefficient ADP times relative efficiency of inefficient ADP.That means that:

Input target=Actual input for inefficient ADP x Relative efficiency for inefficient ADP

Therefore for Gushegu ADP we have:

Input target = (7 staff+3 vehicles) x 0.6643 = 5staff + 2 vehicles.

This means that Gushegu will be efficient if it reduces its number of staff and number of vehicles to 5 and 2 respectively and yielding the same output.

ANSWER REPORT ON GUSHEGU ADP AS THE TARGET DMU-2010

Table 7: Target Cell (Max)

Cell	Name	Original Value	Final value
G6	Gushegu ADP Weighted output	156.75	1

Table 8: Adjustable Cells

Cell	Name	Original Value	Final Value
C9	Completion rate	1	0.006492848
D9	BECE pass rate	1	0.006221174
E9	Number of staff	1	0.166666667
F9	Number of vehicles	1	0

For table 7 and table 8 the optimal solution value of the linear programming is valued at 1.The best input weights are 0.166666667 for number of staff and 0 for number of vehicles. Best output weights are also 0.006492848 for completion rate and 0.006221174 for BECE pass rate.

To maximize efficiency the number of staff of should not increase for the same output. The number of vehicles has neutral effect on maximizing efficiency to get the same output.

IMPROVEMENT FOR SABOBA ADP -2010

To improve the efficiency of Saboba ADP, we set as ADP that is efficient as a benchmark. The following calculations will be useful.

Input target=Actual input for inefficient ADP x Relative efficiency for inefficient ADP

Therefore for Saboba ADP we have:

Input target = (6 staff+3 vehicles) x 0.7024 = 4 staff + 2 vehicles.

This means that Saboba ADP will be efficient if it reduces its number of staff and number of vehicles to 4 and 2 respectively and yielding the same output.

IMPROVEMENT FOR NADOWLI ADP-2010

Nadowli ADP is considered inefficient for the year 2010.It is possible for Nadowli ADP to perform better in its efficiency as that of Gushegu or Zabzugu ADP.Let us use the following procedure to make Nadowli ADP efficient.

Input target=Actual input for inefficient ADP x Relative efficiency for inefficient ADP

Therefore for Nadowli ADP we have:

Input target = (6 staff+2 vehicles) x 0.7849 = 5 staff + 2 vehicles.

This means that Nadowli ADP will be efficient if it reduces its number of staff to 5 and maintain the same number of vehicles which is 2 for the same output.

CHAPTER FIVE

CONCLUSION

There are lots of advantages of DEA which encourage more and more organizations willing to use it in efficiency analysis. The most important one is that it is able to handle multiple inputs and outputs. So DEA is particularly suitable for analyzing the efficiency of an organisation's interventions where it is difficult or impossible to assign value to many of the outputs. For example, it only requires information on output and input quantities when calculating efficiency. The DEA also identifies best practices for the purpose of benchmarking.

The analysis presents the accurate corrective measure for every input and output in order to improve the efficiency of an inefficient ADP. World Vision Ghana may have to reconsider their number of vehicles and staff in an ADP in order to perform more efficiently. We applied Data Envelopment Analysis, using two (2) inputs and two (2) outputs in our analysis. The ADP resources such as number of staff and number of vehicles per ADP were selected as inputs. The outputs being Basic Education Certificate Examination (BECE) pass rate and Basic Education completion rate were selected from each invention District of the ADP in question.

This chapter looks at the major findings and conclusion of the study. It also highlights some recommendations on future research options on ADP efficiency. Two years data thus 2009 and 2010 were collected for this study. The following were findings and

conclusions that were made with respect to efficiency of education projects of some ADPs and how to improve their inefficiencies:

Considering the year 2009, Zabzugu ADP,Sabooba ADP and Nadowli ADP were identified as efficient. These ADPs serve as benchmark to Gushegu ADP which is inefficient. Gushegu ADP may use any of these ADPs as point of reference to adjust its resources in order to become efficient. For Gushegu ADP to be efficient then it has to reduce its number of staff by two and number of vehicles by one.

In the year 2010 Zabzugu ADP and Gushegu ADP were marked out as efficient.Saboba ADP and Nadowli ADP were discovered as inefficient.Saboba ADP and Nadowli ADP may employ Gushegu ADP or Zabzugu ADP as a benchmark in order to adjust their resources to become efficient.Saboba ADP may become efficient if it reduces its staff by 2 and its vehicles by one. Also Nadowli ADP may turn out to be efficient if its staff is reduced by 1 and maintain its number of vehicles.

It has been noticed that the reduction in the number of staff could worsen the current unemployment situation in Ghana. To avoid this phenomenon, it is suggested that instead of laying-off extra hands and vehicles, World Vision could create other avenues for employment in other areas of intervention. Alternatively, they could scale up their interventions to cover other deprived areas of Ghana.

RECOMMENDATIONS

It was not possible to exhaust every avenue of this study due to time, data, and budget constraints. However, additional research may be undertaken to address several unsolved issues as well as broad subjects related to this study.

- We recommend this thesis to World Vision Ghana, to use DEA-CCR model to maximise their efficiency.

- Further studies should be conducted in other interventions of World Vision Ghana in order to maximise the usage of their resources.

- Factors that were controversial (Number of years of ADP and experiences of staff) deserve further attention to evaluate whether or not their effects on efficiency and productivity may be replicated.

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APPENDIX 1

ZABZUGU AADP AS A TARGET DMU-2009

	Completion rate	BECE pass rate	Number of staff	Number of vehicles	Weighted output	Weighted input	Efficiency	Working
Zabzugu ADP	43	60.5	4	2	1	1	1	-5.029E-12
Saboba ADP	83	34.9	3	2	0.956731554	0.956731554	1	-9.12E-11
Gushegu ADP	91.4	36.05	7	3	1.025236041	1.543268446	0.6643277	-0.5180324
Nadowli ADP	65	55.7	6	2	1.086536892	1.086536892	1	-6.684E-11
	0.006527567	0.011889498	0.043268446	0.413463108				

Microsoft Excel 12.0 Answer Report
Worksheet: [Book1]Sheet1
Report Created: 8/1/2012 9:57:15 PM

Target Cell (Max)

Cell	Name	Original Value	Final Value
G6	Zabzugu ADP Weighted output	103.5	1

Adjustable Cells

Cell	Name	Original Value	Final Value
C11	Completion rate	1	0.006527567
D11	BECE pass rate	1	0.011889498
E11	Number of staff	1	0.043268446
F11	Number of vehicles	1	0.413463108

APPENDIX 2

GUSHEGU ADP AS A TARGET DMU-2010

	Completion rate	BECE pass rate	Number of staff	Number of vehicles	Weighted output	Weighted input	Efficiency	Working
Zabzugu ADP	40.1	92.1	5	2	0.833333333	0.833333333	1	-1.88E-10
Saboba ADP	85	24.2	6	3	0.702444456	1	0.70244446	-0.297556
Gushegu ADP	91.4	65.35	6	3	1	1	1	-1.53E-10
Nadowli ADP	61	62.5	6	2	0.784887089	1	0.78488709	-0.215113
	0.006492848	0.006221174	0.166666667	0				

Microsoft Excel 12.0 Answer Report

Worksheet: [Book1]Sheet1

Report Created: 8/2/2012 12:44:25 AM

Target Cell (Max)

Cell	Name	Original Value	Final Value
G6	Gushegu ADP Weighted output	156.75	1

Adjustable Cells

Cell	Name	Original Value	Final Value
C9	Completion rate	1	0.006492848
D9	BECE pass rate	1	0.006221174
E9	Number of staff	1	0.166666667
F9	Number of vehicles	1	0