KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI,

GHANA

Analysis of Technical Efficiency of Public Primary Schools in Ghana:

A Case Study of Ashanti Region

By

AMINARH, Emmanuel Sogah (BA. Economics)

A thesis presented to the Department of Economics, College of Arts and Social Sciences

In partial fulfillment of the requirement for the degree of

MASTER OF PHILOSOPHY IN ECONOMICS

MAY, 2016

DECLARATION

I hereby declare that this submission is my own work towards the Mphil. Economics and to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for award of any degree in other university, except where due acknowledgement has been made in the text.

Aminarh Emmanuel Sogah …………………….. …………………….

(PG9304413) Signature Date

Certified by:

Dr. Eric Fosu Oteng-Abayie ……………………… ………………………

(Supervisor) Signature Date

Certified by:

Dr. Hadrat M. Yusif ……………………… ……………………….

(Internal Supervisor) Signature Date

Certified by:

Dr. Hadrat M. Yusif ………………………. ………………………

(Head of Department) Signature Date

ABSTRACT

Education is undoubtedly an effective and catalytic tool for economic development of a country. This is the reason why Ghana has invested substantial proportion of her limited resources in the basic education to provide a strong foundation to the education system in the country. However, this investment does not appear to translate into a clear improvement of pupil performance. Most people expect that after investing over 25% of the national budget in education, it will naturally translate into impressive results. The standardized test scores of the primary schools as reported by National Education Assessment (NEA) in 2014 have been disappointing with increasing number of failures.

This study applies the stochastic frontier approach to measure the technical efficiency and its determinants for forty sampled public primary schools in Ashanti Region of Ghana. Findings revealed that pupil-teacher ratio and teacher's experience are associated with standardized test score of pupils. Results from the maximum likelihood estimate of the stochastic frontier showed that on average, public primary schools were 0.869 technically efficient; suggesting that about 13.1% of learning outcome could not be realized due to inefficiency. The study also showed that poverty and geographical location of a school are significant determinants of technical efficiencies of the public primary schools. The return to scale that explains the productivity level of schools was less than one, implying a decreasing return to scale.

To improve performance and technical efficiency in public primary schools, the study recommends stakeholders and policy makers to adopt measures to lower pupil-teacher ratio and

improve teaching skills of teachers. Additionally, the government should take steps to reduce poverty levels in the rural areas and improve instructional materials in the rural primary schools.

ACKNOWLEDGEMENT

First and foremost, the greatest thanks go to the Almighty God for helping me in my up and down, granting wisdom, protection and courage throughout my school life.

I wish to extend my profound gratitude to all the hardworking staff and lectures of the Economics Department for granting me the opportunity to pursue this course in the university and for the love and knowledge they have given me. I want to also extend my heartfelt thanks to my supervisor, Dr. Eric F. Oteng-Abayie whose constructive criticism, advice and encouragement has made this work successful.

Special appreciation goes to Michael Azu, Kwabena Narh, Moses Aminarh, Madam Doris Azu, Madam Mary Koryo, Gifty Mensah, and Aminarh Gifty for their support and invaluable suggestions

To my family I give my heartfelt thanks and appreciation for their support and encouragement

DEDICATION

I dedicate this work to Almighty God and the whole members of my family.

TABLE OF CONTENT

PAGE

LIST OF TABLES:

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In an attempt to provide quality education to all Ghanaians to make them functional citizens to contribute to the development of the country, Ghana like other countries has devoted considerable amount of resources to the education sector in order to develop the necessary human capital needed for sustainable economic growth. Currently, the proportion of GDP and budgetary expenditure on education in Ghana is one of the highest in Africa. The actual education expenditure in Ghana as a percentage of GDP increased from 5.6% in 2003 to 6.3 % in
2011 which is above the average for all African countries combined (NEA technical report, 2014). It is significant to note that, Ghana's expenditure on education has been between 25% and 40% of its annual budget (CEPA, 2000). But one important issue which has been of great concern to stakeholders in education and noted by various researchers is the divergence in educational investment and school performance. While real expenditure per pupil continues to increase in public education, the pupils' performance, which is normally measured by standardized test scores, has not increased; it either declines or stagnates. Several concerns have been raised in the media and among civil society on the appalling proficiency levels of pupils in the most fundamental areas- reading, writing and arithmetic.

Academic performance of pupils at the basic levels of education in Ghana continues to show signs of persistent decline despite huge public spending. According to the 2013 Ghana National Education Assessment report, approximately 40% of the pupils in both the 3rd and 6th grades of the primary schools failed to achieve minimum competency in mathematics and approximately

40% of the 3rd grade pupils also failed to attain minimum competency in English (GNECC, 2014). Worse yet, over the past decade, a total of 1,562,270 pupils failed their BECE examination out of a total number of 3,669,138 representing almost 50% (Ghanaian Times, August 2014). The falling pupils' performance in the face of rising expenditure per pupil raises a lot of issues about efficiency in the application of the sector's resources. Ghana has turned out considerable amounts of resources into the education sector but the outcome in terms of pupils' performance has been disappointing (CEPA, 2000).

One possible reason for these abysmal performances is inefficient utilization of resources. Kuhry (2012) interpreted this seeming discontinuity that exists between educational expenditures and pupils' performance as a sign of inefficiency within the education sector. Grosskopf et al (1997) also observed that most schools do operate below the production frontier and suggested that education spending in most countries could be reduced by up to 30%, yet still achieve the same learning outcomes, if the schools were operated efficiently. The UNESCO defined efficiency as the ability to maximize outcome without wasting resources (using least amount of resources feasible).

Quality education may be an important determinant of pupils' enrollment in a country's basic education (CEPA, 2000). Due to poor quality of education service that is being produced by the Ghana education system, significant number of pupils in the rural areas goes through the basic education system without knowing how to read nor write their names. If this continues, parents may feel reluctant to enroll their wards in school because the desired skills or result they are looking for is not realized. An important way education can contribute to the economic strengthening of the country is through increasing the efficiency of the education system (Swati, 2012).

Resource constraints make increasing efficiency very important. An improvement in education efficiency would allow education units to produce more output at lower cost and permits the release of resources to other sectors of the economy. Academic performance of pupils can improve tremendously if the basic schools are more efficient in their application of the resources at their disposal (CEPA, 2000). Raising school output through improved efficiency does not require additional resource. This is agreed with the view point of Adu (2010) cited in Adeyemi and Adu (2012) who reported that, the more efficient the educational systems is, the less fund it would require to fulfill its objectives.

1.2 Problem Statement

Education contributes immensely to the development and improvement of human capital which is a necessary driver for economic growth. Sound education also helps a population to make informed decisions that promote good health, nutrition, population control etc. Following these important benefits, it will be disheartening should Ghana fail to realize these contributions due to inefficiency.

Ghana is determined to applying greater part of her available resources to educate or enlighten her citizens. The total government spending on education tripled from 0.53 million Ghana cedis in 2003 to 1.7 million Ghana cedis in 2011 (NEA technical report, 2014). According to Forum for Education Reforms (FFER), the country's expenditure on education alone is estimated to be more than 6% of GDP as against a global average of about 5%. Notwithstanding this huge investment and various interventions, performance of the pupils at various public primary schools in Ghana is still low and appears not to be improving commensurately.

The first Early Grade Reading Assessment (EGRA) conducted in 2013 revealed that by the end of the 2nd grade or class two, most of pupils in the public schools could not yet read with comprehension—neither in English nor in Ghanaian language (GNECC, 2014).

The performance of the public basic school system is characterized by significant inefficiency (Education performance report, 2012) and for a poor country like Ghana, such inefficiency is a cost that cannot be accommodated (CEPA, 2000). Since education is largely financed with taxes collected from citizens, inefficiency in education production would amount to misuse of tax resources (Chakarborty, 2009). These resources could be used elsewhere; expenditure on school buildings entails forgoing house and office building, so also expenditure on teachers' salaries represents employment opportunities forgone in some other sectors of the economy.

The low quality of education at the basic level in the face of huge expenditure government has been incurring on training and remunerating teachers, expanding and improving school infrastructure clearly showed that pumping of resources into the education sector by itself is not enough to alleviate the sector from the challenges it is facing. It is important that the resources of the sector are strictly monitored and efficiently used to achieve results (CEPA, 2000).

Despite strides made by successive governments in the sector, poor conditions such as lack of learning materials (textbooks, syllabus etc.) and trained teachers, poor infrastructure and libraries which have been marked as factors that worsen performance still exist in some public primary schools. For instance, (GNECC, 2014) reported that, the distribution of teachers, despite the efforts being made by government is still a challenge as evidenced by the GES monitoring which indicated an over 27,000 teacher deficit in deprived districts. Rapid growth of the education sector in terms of pupil enrollment without corresponding increases in teachers and other instructional materials in some parts of the country is a major factor which accounts for poor academic performance. Some schools may ensure efficient use of available resources but their problem might be inadequate supply of trained teachers and instructional materials. Pupil's enrollment may increase while critical inputs would not expand to support the increases in enrolment. The inefficiencies are also driven by population growth which generates a high demand for school places while growth in school infrastructure lagged behind.

In most developed countries, the importance of a quality and efficient education system has attracted a lot of attention especially from education researchers. This has provided important information to government and other stakeholders in these countries about education production and efficiency differences among schools and possible factors that might affect school efficiency (Hanushek, 1979). In contrast, there has not been much work done with regards to efficiency of the education sector in Ghana and Africa as a whole and therefore there is no empirical basis for understanding the scale and nature of inefficiency in schools. Therefore little is known about how efficiency differs across schools in different localities i.e. between rural and urban areas

The aim of this study is to analyze the level of efficiency with which resources are applied in public primary schools. This study will provide ample knowledge on efficiency of public primary schools that would help stakeholders improve the quality of education and achieve greater efficiency in public education production, so as to better contribute to the needs of society and the nation as a whole.

1.3 Research Questions

The following questions have been raised to guide the study:

1. What is the level of technical efficiency of sampled public primary schools in Ashanti Region?
2. What determinants influence the technical efficiency of public primary schools in Ashanti Region?

1.4 Objectives of the Study

The main objective of the study is to evaluate the level of technical efficiency of public primary schools in Ghana using stochastic frontier analysis (SFA) focusing on 2012/13 academic year. Specific objectives to be achieved in this study include the following:

i. To empirically examined the presence of inefficiency in the public primary schools in Ashanti Region.

ii. To determine the factors that influence the technical efficiency among sampled public primary schools in Ashanti Region.

1.5 Methodology

This section looks at the data collection, interpretation and analysis tools that will be employed in this study. The research used secondary data which were sourced from the National, Regional and District Education Offices in Ashanti region of Ghana.

Data on inputs, this study intends to use for the analysis are the student/teacher ratio, number of classrooms, percentage of teachers with diploma in education, percentage of teachers with at least 10 years of teaching experience. With regards to output, the study will use the standardized test scores of National Education Assessment (NEA) conducted by Ministry of Education for primary three and six in 2012 / 2013 academic year. The study chose this output because according to Ghana Education Service (GES), the NEA is the only standardized test currently undertaken, measuring learning outcomes in English and Mathematics at 3th and 6th grade levels using two criteria for competency: the less stringent minimal competency and proficiency (Education sector performance report, 2012). Data interpretation, presentation and analysis, quantitative methods will also be used.

Stochastic Frontier Approach (SFA) will be used for data input and the analysis. The estimation of production functions has been given momentum by the emergence of the stochastic frontier. This model has a disturbance term composed of two sections; a one-sided component, nonnegative for production functions which represent the level of inefficiency, and a symmetric component representing the normal statistical noise that characterizes any functional relationship. The study will use this model because its formulation appears to have alleviated most of the statistical challenges of earlier attempts at estimating frontiers, such as linear programming methodologies.

1.6 Hypothesis Statement.

H_0: The public primary schools in Ashanti Region are technically efficient

H_1: The public primary schools in Ashanti Region are technically inefficient

1.7 Significance/Justification of the Study

The study places significant premium on primary education because its level of quality can have consequential impact on the entire education system and general development of the country. For this reason, the falling standard of basic education in Ghana should be a great concern to government and other stakeholders which must lead to critical examination of the basic school system. The study would contribute to the general understanding of various school resources or inputs that influence academic performance of pupils in the basic schools.

Furthermore, resource constraints in education are expected to worsen due to high population growth and perhaps increase demands from other equally important sectors. This suggests that schools must know how efficiently allocated resources should be transformed into learning outcomes in primary education subsector. The result of this study will better inform government about the efficiency levels of the schools and how they could be assisted to improve their efficiency.

Since children's educational achievement depends on both discretionary and non-discretionary resources, it is important that research such as this is conducted to identify the school-specific factors that affect school efficiency. This will assist in formulation of government policies that will guide in allocation of resources to effect changes in the sector to improve learning.

Efficiency in education is important given that resources are scarce and an efficient education system is the foundation of economic prosperity yet very little attention is given to efficiency assessment of primary schools and education in general in Ghana.

Generally, the findings of this study would be useful to government, stakeholders in the educational sector and other organizations in Ghana to address the problem of inefficient use of resource and enhance student performance in the education sector.

1.8 Organization of the Study

This paper is organized into five chapters. The chapter one encompasses the introduction of the study, problem statement as well as research questions. Other items contain in this chapter include the methodology, statement of hypothesis and the significance of the study

Chapter two talks about review of the documented literature related to the study so as to draw inferences.

Chapter three gives a detailed methodology that explains the source of data, methodology used in the data collection and the technique of data analysis.

Chapter four presents data analysis and discusses findings from chapter three. Chapter five being the final chapter contains a summary of our findings, recommendations and conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter basically looks at current knowledge which covers substantive findings, as well as theoretical and methodological contributions to measurement of technical efficiency. It also tries to review studies of previous writers on the topic under consideration. This chapter is divided into six parts;

i. Basic education in Ghana.

ii. Theory of microeconomic efficiency measurement.

iii. Methodological contributions to efficiency measurement iv. Inputs and Outputs choices in education

v. Socioeconomic status and education efficiency vi. Empirical review.

2.2 Basic education in Ghana

Ghana presently has a 2-6-3 basic education system. The Ghana's basic education is free and compulsory. This type of education can be described as a minimum period of schooling required to ensure that children get basic numeracy, literacy, and skills necessary to solve simple problems. The basic education system runs from kindergarten, primary school up to junior high school.

Various post-independence reforms had greatly affected enrolment and quality of education in the basic education. The aim of 1961 Act, (Act 87) enacted by Dr. Kwame Nkrumah was to achieve free universal primary education. This reform had increased enrolment in primary one by more than doubled between 1960/61 and 1961/62. However, the enrolments rate dropped in 1964. This downturn in enrolment rates has been blamed on reintroduction of tuition fees after the increase in enrolments when the policy of tuition free primary education was introduced (CEPA, 2000)

Enrolments in primary education almost double in the past years after the Free and Compulsory Universal Basic Education (FCUBE) together with the capitation grant were introduced. For instance, enrolment in the primary education had increased from 2.5 million in 1999/2000 school year to 4.45 million in 2011/2012 (Education Assessment Technical Report, 2014). Enrolment gains have been made across Ghana, even in some of the most impoverished and remote areas of the country, such as Northern sections of the country.

In spite of overall gains in enrolment, irregular attendance and late entry into primary school remain serious problems for children from impoverished homes and rural settings. Data from 2010 indicated that in rural areas, approximately 60% of 6-year-old children and 45% of 7-yearold children were not in school, while in urban areas, 43% of age 6 and 23% of age 7 children were not in school (Education Assessment Technical Report, 2014).

Children from rural areas, particularly in the north, depend heavily on public education. In the 2010/2011 school year, an average of 4.3% of enrolments in the three regions of the north combined were in private schools, compared to the national average of 20% and approximately 29% in the urban capitals of Ashanti and Greater Accra Region.

The rapid expansion of enrolment to a certain extent is at the cost of the quality of education. A huge increase in enrollment compromised quality because there is insufficient supply of resources to support the growth in enrolments. The supply of classrooms and trained teachers for example, could not equal the growth rate in enrolments.

The distribution of resources, particularly trained teachers, favours the urban and wealthier districts and thus plays an important factor in inequities observed in learning outcomes. In spite of increased expenditure in education in the past decade, inequities in education resources across urban/rural and poor/wealthy lines have worsened rather than attenuated.

The quantity of untrained teachers was not the only relevant factor in regions that were poor, rural and/or in the north. In addition, classrooms were more crowded in schools in the poorest districts, with pupil–teacher ratios in the two highest wealth quintiles averaging 63 and in the two lowest wealth quintiles, 117 pupils per teacher (Education Sector Performance Report, 2012).

Non-teacher inputs also fared worse in the poorest regions, especially in the deprived districts. Schools in the deprived districts had fewer primary textbooks, classrooms, potable water sources, and toilets.

Findings from previous National Educational Assessment (NEA) administrations noted the disparities in learning outcomes, consistently showing poorer performance for pupils in the rural as opposed to urban regions, especially in the north. The Basic Education Certificate Examination (BECE) pass rates also have underscored the poor performance of students in the rural and impoverished regions of the country.

Quality of education is very important for the improvement of enrolment in primary schools and rising literacy and numeracy levels in the country. To do this, there is need for resource enhancement at the kindergarten and primary schools to lay quality foundation for the country's education system. Adequate instructional materials should be made available in the classrooms to ensure effective learning and teaching process. Efficient and well-motivated teachers, equipped classrooms and effective supervision at the basic education level are what are required to solve the problem of poor results.

2.3 Theory of Microeconomic Efficiency Measurement

The theory underpinning efficiency analysis lies in production theory. In production theory, production is maximized by firms (Fried, Lovell, & Schmidt, 2008). The basic principles for all efficiency measures is that output of goods and services per unit of input must be attained without waste (Ajibefun and Daramola, 1999)

Microeconomic efficiency measurement begins with Farrell (1957) who defined a simple measure of firm efficiency that could account for multiple inputs within the context of technical and allocative efficiency and argued that measuring technical efficiency is important because it allows production units to determine whether outputs can be increased simply by raising efficiency, without increasing input quantities.

Following Farrell (1957), efficiency of an education unit can be divided into two components: technical and allocative efficiencies. According to Forsund et al (1980), technical efficiency explains the firm's ability to generate maximum amount of output given the quantity of inputs they use. To (Kirjavainen, 2009), technical efficiency is determined either as the ratio of observed to maximum potential outputs obtainable from the given inputs or as the ratio of the minimum potential to observed inputs required to produce the given output. In the former case, a school is viewed as maximizing its output with the given inputs and in the latter case as minimizing the use of inputs when the output is fixed. Within the context of education, Andrew (2001) refers to technical efficiency as the physical relationship between the inputs and educational output. These outputs may either be measured in terms of intermediate outputs, for instance test scores or a final education output such as graduates' employment rates or acceptance rates into tertiary education. Allocative efficiency involves selecting different technically efficient combinations of inputs to produce maximum possible outputs. Allocative efficiency, essentially, answers the question, for instance, whether or not a school wants more or less trained teachers for its academic accomplishments (Haelermans, 2009). The sum of the two yields the level of economic efficiency

Efficiency measurement compares the actual performance of a production unit and the best possible performance for the unit. Similarly, in education efficiency research, schools which are the production units are benchmarked based on their present production relative to the best performing school.

The production frontier is typically used to analyze efficiency in most empirical research. The production frontier defines the maximum output produce from a given set of inputs and technology (Haelermans, 2009). Underlying the frontier methodology is the assumption that a school producing at a point within the frontier is technically inefficient (Coelli et al., 1998). Inefficiency is measured as the extent at which schools use available inputs to produce a given level of educational output relative to the best practice schools in the sample. Once the frontier has been defined, the location of any school relative to the frontier can be identified and interpreted as a measure of its relative efficiency. Generally, the true optimal situation is not known, an estimate of this frontier is required, which is usually known as the best-practice frontier. The maximization of production, revenue or profits, or the minimization of costs is represented by the best-practice frontier (Fried et al., 2008).

In most technical efficiency analysis, a production frontier which defines the minimum input bundle needed to produce different levels of outputs, or the maximum amount of output producible with different inputs bundles is estimated, hence schools that are found on the frontier are considered best-practice or technically efficient schools, and score an efficiency value of one. However, schools that are found within the frontier score an efficiency value relative to the bestperforming schools.

2.4 Methodological Contributions of Efficiency Measurement

The output in the education sector has no clear-cut definition and not palpable in many ways. This makes it difficult to specify a supply function in the general form. According to Sheenan (1973), it is very problematic to define a unit of output "because educational system usually in practice has no common distinct function, so also it has no single distinct indicator of output."

The fact that public sector produces goods that are economically free at the point of use implies that the prices of outputs are not determined by forces of demand and supply (Sutherland, Price and Gonand, 2009). As a result, efficiency cannot be directly estimated; an approach is required to proxy the efficiency frontier which would permit relatively accurate benchmarking.

There are many approaches use in measuring technical efficiency but Data Envelopment Analysis and Stochastic Frontier Approach are the most widely used methods for measuring education efficiency levels in empirical research. To a large extent, these are competing methodologies.

However, both approaches come with their strengths and weaknesses influencing the results in a particular application.

DEA was formulated by Chames Cooper and Rhodes as a non-parametric linear programming model for measuring relative efficiency of organization units called Decision-Making Units (DMUs). The Data Envelopment Analysis (DEA) applies mathematical programming in its analysis. In this method the estimation of technical efficiency is based on mathematical programming and this involves estimating a production frontier over a convex envelope curve developed by line segments linking actual efficient production units. Although, the Data Envelopment Approach has been used in many literatures, it has a number of shortcomings that make it difficult to be used for a particular study: Data Envelopment Analysis generate efficiency scores which are point estimates. This makes it impossible to construct standard errors and confidence intervals (Mastromarco, 2008). Again the DEA is weak in its sensitivity to errors in the data. This is a serious problem, especially if there are only few observations determining the efficiency frontier (Kirjuvainen, 2009). The non-parametric approach is not stochastic and therefore its efficiency estimates are contaminated with several sources of statistical noise. In conclusion, nonparametric methods, problematically assumed that every variation in a firm performance is largely due to inefficiency.

According to Forsund et al (1980), this conclusion is illogical because every empirical relationship supposes to contain statistical noise in its formulation. A simple explanation of this is that, the dependent variables may have measurement inaccuracies which can affect the efficiency estimates. Also, wrong specification of the model or measurement of its component variables, including the output, could translate into increased inefficiency measures. These two arguments outlined make it unreasonable if the stochastic noise is not distinguished from the inefficiency term. However the characterizing feature and main advantage of the Data Envelopment Analysis, is that it involves no functional form on the data for the analysis.

Stochastic frontier analysis (SFA) which presents an improvement over the traditional average production function and other deterministic functions is based on the estimate of the stochastic frontier production function.

An important idea about the SFA is that unlike the DEA, the error term is composed of two. A stochastic component which allows random variation of the frontier across firms and accounts for the effects of wrong measurement, statistical noise and other random shocks beyond the control of the firm. The other one is the one-sided component that accounts for the effects of inefficiency in relation to the stochastic frontier. The inefficiency error represents a deviation of output from the maximal possible value.

The stochastic frontier analysis developed simultaneously by Aigner et al. [1977] and Meeusen and van den Broeck [1977] is composed of three parts: the deterministic production function, the random error and the inefficiency error. This approach is usually call "composed error model" since the error term has two components.

The general formulation of the stochastic frontier model is

$$y_i = f(x_{ji}; \beta) + {}_i \text{ ....} \quad (1)$$

(i = 1, 2, 3,…, N), where y_i = the output for firm i, x_i = inputs for firm i, β =parameters and ε_i = error term for firm i.

Residual random variable, ε_i, in the equation (1) is specified as

$_{i} = v_i - u_i$…………………………………………….. (2)

Where v_i is assumed to be independently and identically distributed as a normal random variable with zero mean and variance $\sigma_{v,}^2$ and independent of the u_i, which is assumed to be non-negative truncations of the normal distribution with mean, μ, and variance, σ_u^2. The variance of ε_i is given by $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The disintegration of the residual random variable, ε_i, in the production function in equation (1), as specified in equation (2), is the decisive property which defines the SFA production function. The variable, v_i, a random error in the equation (2) is assumed to be involved in the normal linear regression capturing the effects of statistical noise, measurement error, and other external shocks outside the control peripheral of the producer. The mean of this random error term is zero. The second term, u_i, is a non-negative firm effect variation, which is assumed to account for the presence of technical inefficiency of the production of the firm. The mean of the firm effect term is zero for a half-normally truncated distribution. If u_i is nonexistent then a firm is producing on the stochastic frontier and is considered technically efficient. If $u_i > 0$, then the firm is deem to be operating below the production frontier and is described to be inefficient. If the random term, u_i in the model turns zero then, the equation (1) changes to an average production function used in most econometric estimations. Alternatively, if the random disturbance v_i is absent from equation (1), the model, reduces to a deterministic frontier often estimated by Data Envelopment Analysis which uses linear programming techniques

The economic logic behind equation (1) is that production procedure is connected to two distinct random errors with different features. The condition that $u_i \geq 0$ forces all sample firms to either lie on or below the stochastic production frontier. Essentially, the economic interpretation of the one sided u_i, component is that production of each firm must lie either on or under the production frontier. Any deviation from the frontier is largely due to technical inefficiency of the firm. If these efficiencies could be removed, the firm would produce on the frontier.

Another important issue in stochastic frontier model is the assumptions about u_i. The one–sided error is associated with a number of distributions, which could reasonably be assumed to represent the distribution of the shortfall of output from the frontier. Aigner et al. (1977) considered exponential half-normal and exponential distributions, while Meeusen and van den Broeck (1977) considered exponential ones. In most empirical research, however, the error term u_i is generally assumed one of the following three distributions: half-normal, truncated normal at zero and Exponential. Several researchers considered the half-normal and truncated normal distributions because it is easy to estimate and interpret. Many of the past stochastic production frontier analysis only estimated average technical inefficiency of firms because they could not segregate the residual for individual observations into the random and efficiency errors components. However this problem has been solved by Jondrow et al. (1982). He suggested a method for decomposition using the conditional distribution of u_i given the total disturbance ε_i

The stochastic frontier approach (SFA) has advantage over DEA of not attributing measurement errors and other stochastic noise to the efficiency scores. However, it involves assumption of a specific functional form and distribution of the non-random error terms.

In this thesis, the study employs the stochastic frontier methodology in measuring the technical efficiency of the public primary schools in the Ashanti region of Ghana

2.5 Inputs and Outputs choices in education

Efficiency measurement in the education production has been challenging due to difficulties involve in assessing credible data. Panel data on education at the national level are scarce, while the credible set of school-level data are essentially limited to cross section data, this restricts the analysis of technical efficiency to a particular point in time.

2.5.1 Choice of outcomes

If the aim is to achieve more desired outcome from a little resource available then it is imperative that emphatic position is made on what the education system should accomplish. Efficient society is able to obtain maximum output relative to the level of resources invested, but if the outcome fall short of what is actually desired then the system is inefficient.

There is a central question about who decides what should count as desirable outcome. Education researchers have been battling with longstanding and ongoing debate over what should be considered as a single output or outcome in education production. For instance, number of student graduating per year, number of student success in securing admission into the higher education, standardized test score, dropout and enrollment rates were once used as output by researchers in efficiency estimation in education. It is important that societies or nations clearly defined or identified outcome they require from their educational system. This should be a standard driven initiative where general pronouncement is made by the nation about the collective expectation for what education system seeks to accomplish

Critics of efficiency measurement in education are concern that ease of measurement in education can unjustifiably influenced the choice of outcome the system seeks to achieve. The worry is that the drive for efficiency estimation can lead to the use of education outcome that are easily measured than the actual outcome that have long term value for individual students and the larger society. The use of standardized test score as an output for tertiary institutions instead of basic schools has been criticized on this ground.

Interests in the economic consequences of schooling occasionally arise and this interest has impelled many researchers to use earning after school, as a means of measuring school outcome. Some literatures on economics of education had made frantic effort to estimate economic return to different level and type of education. Here, using return as educational output is challenging because earnings are influenced by many factors and it is difficult to isolate the effect of schooling.

There are measurement issues arising from collective nature of schooling. The level of lesson understanding in a class is likely to vary among individual students and this prompted the question about how best to access output for a group of pupils and an individual student in the group. If one is interested in average class performance, then important concern should be leveled to what is happening to the level of variation that exist across the entire student within the classroom.

The education efficiency researches in the past had placed much premium on average test score result for relatively large unit like school district and not individual schools. State university (2014): Inputs and Outputs choices in education: http://education. State university.com (accessed November 12, 2014)

2.5.2 Choice of inputs

The outputs that are chosen determine inputs for the entire system. Unlike, the outputs, the input issues are more straightforward and they are relatively easy to define. Once the output to be produced is known, at what level, and for what category of people, society can then turn to the challenge of doing so in as economical way that is possible. Besides, the objective is to achieve the desired outcome for as little cost as possible, and this requires making the best possible use of whatever resources are available

Two main types of input are available in education: discretionary and non-discretionary. The discretionary inputs consist of educational resources that fall under the direct control of the school management. Discretionary inputs can be expressed in physical inputs such as pupilteacher ratio, class size, teacher experience and level of qualification. Discretionary inputs may also be defined in terms of national expenditure on basic and other categories of education. Nondiscretionary inputs relate to socioeconomic and environmental inputs that cannot be controlled and manipulated by the school management. According to literature, pupil performance is considered to be dependent on family background and innate ability. While it is difficult to measure these socioeconomic and environment factors, (Sutherland, Price and Gonand, 2009) explained how they could be proxied by socio-economic status.

2.6 Socioeconomic Status and Education Efficiency

Although socioeconomic factors are not at the discretion of the school management, they do influence the outcome of education production process (Pereira and Moreira, 2007). According to

(Sutherland, Price and Gonand, 2009) pupils' academic success is considered to be dependent on family background and innate ability. While resource of the school and expenditure on pupil can directly affect education outcomes, the empirical finding suggests that background of parents and student characteristics have greater effect on performance. This explains the reason why government expenditure on education has not curtailed the wide differences in test score that are still observed.

The studies evaluating inefficiency with regards to resource use in public education constantly found pupils' socioeconomic factors such as parental education and family background etc play a far significant role than school inputs in explaining differences in test scores of students (Chakraborty, 2009).

The studies done by Hanushek (1986) and Grosskopf and Weber (1989) find a significant influence of socioeconomic status and environmental factors on achievement scores. (Hanushek, 1989) also analyzed about 20yrs of educational production studies and concluded that variances in school expenditure do not explain the variances in school outcomes. Family background however explains the variances in outcomes. He concluded that pupils with richer and educated parents perform better.

According to Coleman's (1966) study on Equality of Educational Opportunity, socioeconomic status is a strong predictor of pupil achievement. (Coleman et al., 1966) conducted a study to determine the most important inputs that influence achievement of pupil in school. The study revealed that a background of the family and characteristics of pupil in schools were most important determinants of pupil's achievement and that difference in schools spending has little to do with pupils' achievements.

2.7 Empirical Review

Empirical studies that investigated efficient utilization of resources in education use both parametric and non-parametric approaches in their analysis. While most of these efficiency literatures focused on determinants of efficiency few others only analyzed the efficiency with which resources are utilized. The empirical review in this study is divided into two: review on efficiency and review on determinants of efficiency.

2.7.1 Review on Efficiency

Ergulen et al (2009) analyzed technical efficiency across high schools in Nigde province of Turkey for the period 2004-2005. The study found average efficiency scores of 61.7% and 68.6% for the constant and variable returns methodology respectively. The schools that were found to be efficient using CRS were also found to be efficient using VRS and appeared frequently as reference set for inefficient schools

Adeyemi and Adu (2012) investigating teachers' quality and efficiency in primary schools in Nigeria concluded that teacher quality is critical and predictor of efficiency in primary school in Ekiti state.

Grosskopf et al (1997) conducted a study on education efficiency concluded that education production is generally characterized with significant inefficiency and suggested that education expenditure in many countries could be reduced by up to 30% and still attain the same outcome if schools were producing efficiently.

Adeyemi (2012) examined school variables and efficiency of senior high schools in Ondo State and concluded that school variables are crucial and are function of efficiency in high school in, Nigeria.

Kirjavainen (2007) tested the truncated normal distribution for the pooled panel data model and random effect model. The study found that parent's education level and share of white collar jobs increased achievement whereas share of single parent's decreased achievement. Average length of studies was also found to affect achievement negatively. Student-teacher ratio was significant in all the models except the fixed effects model; it affects achievement positively in all the models.

Aristovnik (2011) analyzed efficiency of education spending in central and Eastern Europe and found out that technical efficiency in education sector differs significantly across many of Europeans and OECD countries. The study revealed that Central and Eastern European countries exhibited comparatively high efficiency in higher education. The assessment established that majority of the Eastern and Central European countries have a great potential for increased efficiency in spending of scarce education resources.

Chakraborty, Biswas and Lewis (1999) estimated technical efficiency in public education in Utah. Considerable variations in technical efficiency were detected among school districts. The empirical results established that the single most important factor explaining students' academic achievement is education level of parents of students. Investigation of efficiency also showed that socioeconomic and environmental factors have a strong impact on student achievement.

Aaltonen (2006) measured efficiency differences and productivity changes in a schools at Finnish municipalities. The mean inefficiency was estimated at 6% to10% during 1998-2004 based on both production and cost function estimations. The results showed that average cost efficiency in school education was 81% with VRS specification and 77% for CRS accounting for the years 1998-2004.The panel data estimations showed that the overall inefficiency using true fixed effects estimates is between 11.9% and 13.3% for truncated normal and half normal respectively. For the pooled panel data inefficiency scores found were 11.2% for truncated normal and 8.3% for half normal distribution.

Millimet and Collier (2004) assessed the effects of competition on the efficiency of public school district for the period 1997-1998. The results from the study revealed considerable differences in the level of inefficiency across the districts. Some evidence of strategic competition and spatial spillover has been established. Ultimately the results showed that improvement in neighboring efficiency and potential scores generate positive spillovers

Mancebon et al (2000) assessed the efficiency of Southampon and Portsmouth primary schools and concluded that religious orientation and parental influence have significant impact on the ability of a school to deliver the best possible outcome in standardized assessment test.

2.7.2 Review on Determinant of Efficiency.

Pereira et al (2007) estimated level of efficiency and its determinants in the utilization of resources in secondary schools of Portugal. The study revealed existence of technical inefficiency. The mean efficiency scores of 83% without environmental variables and 84% with environmental variables were found. According to the study, teacher seniority, proxied by age, appears important for educational output. The study indicated that the ‘quality’ of teachers has more effect on output than the ‘quantity. The study further demonstrated a sizeable influence of geographical location of schools on outcome.

Muvawala and Hisali (August, 2012) estimated the technical efficiency and its determinants for Uganda’s primary for the 2001-to-2008 period. The model and data the study employed for government-aided and private schools showed significant evidence of technical efficiency. The study concluded that government-aided schools are more efficient than the private school while urban schools are less efficient than rural schools. The study found out that factors such as house of teachers, classrooms, inspection by education officers and desks are most important determinant of technical efficiency for government schools.

Esmaeili (2015) used the one-staged estimation model to analyzed the technical efficiency and its determinants of Iranian Persian fishing industry. The study showed consideration technical efficiency in the industry. The result established that wooden vessel was more efficient as compared to fiberglass. While possession of two-way ratio and GIP were found to be significant determinants for efficiency in the industry, shippers level of education and experience have been found to be important crew qualities that effect efficiency

Chakraborty (2009) used one stage procedure to analyze the roles that socio-economic and environmental factors play in education efficiency determination. The study showed that inefficiency of school increase over time. Additionally, the results of the study further revealed that poverty and minority variables play a very significant role in determining efficiency in education

Franta, Prague and Konečny (2009) assessed technical efficiency of Czech grammar schools. The average class size was positive and statistically significant. According to the findings, unemployment ratio and relative salaries estimation suggest a remarkable effect of external factors. The study established that difference between direct measure of school achievement and indirect indicators increase over time.

Mizala, Romaguera and Farren (2002) measured the technical efficiency of Chilean schools. The result of the study showed that the larger the class the more poorly students perform. The study indicated that private fee-paying schools are more efficient than public schools. Furthermore, the findings also showed that socioeconomic variables are very important in determining pupil success and that pupils from low socioeconomic status perform more poorly, on average, than pupils from rich families and education levels.

Mohd Arshad (2012) examined Technical Efficiency and its determinants of Public Primary Schools in Tasmania. The study found out that technical inefficiency is positively associated with students' suspension rates. Also, a mothers' occupational status had a significant negative effect on technical inefficiency. The results of the study again found that students who had English as a second language, the number of disability students, students' absenteeism rate and a school located in rural are negatively related to schools' technical efficiency. Through the study, it was found that urban schools were more scale efficient than rural schools

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter explicitly explained the models and research methodology employed in the study. It describes the study area and outlines the sources of data, type of data, model specifications (stochastic frontier and inefficiency error term models) and assumptions of the models. It also includes tools and method used in analyzing the data collected.

3.2 Description of the Study Area

Ghana has ten political regions. The Ashanti region which is one of the regions is located in the center of Ghana. This region is surrounded with four of the remaining regions, Eastern region in the east, Brong-Ahafo in the north, Western region in the south west and Central region in the south. It is located between longitudes 0.15W and 2.25W and latitudes 5.50N and 7.46N. The region has one metropolitan, six municipals and thirteen districts. It has 6118 basic schools consisting of 104 nurseries, 2160 kindergartens, 2263 primary and 1591 JHS (MoE Basic Report, 2012/2013).

Comparatively, the Ashanti region comes on top of other regions in terms of number of basic schools it has. This implies that, government expenditure on basic education in this region is higher relative to other individual regions. There is the need for investigation into whether resources assign to basic education in this region are efficiently applied towards improving academic performance of pupils in the basic schools.

This paper centered its study on the Ashanti Region because the report on National Education Assessment in 2014 has showed that the region has performed abysmally despite huge expenditure government has been incurring to improve quality of education in the area.

3.3 Methodological Framework

Two main approaches are available for the estimation of technical efficiency in empirical research. These are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA).

DEA is a non-parametric approach which uses mathematical programming to identify the efficient frontier. The production frontier which is normally used in the non-parametric approach is deterministic and that any deviation from the frontier's output is attributed to inefficiency.

The SFA is a parametric approach that hypothesis a function form and econometrically estimates the stochastic production function. The production frontier function involved in this approach is sensitive to random shocks, so provision is made for stochastic error term in the model to capture the measurement errors and other random effects. As a result, any deviation that is caused by controllable decisions of the firm is attributed to inefficiency (Esmaeili, 2015). The difference between SFA and DEA models is the way they treat the random disturbance.

Although, the stochastic frontier approach is more demanding with regards to the functional form of the production function and assumptions on the error terms, it is widely used in several literatures for the estimation of technical efficiency of schools. For example Chakraborty, Biswas and Lewis (1999), Pereira et al (2007), Chakraborty (2009), Barrow (1991), Grosskopf et al (1997)

, Muvawala and Hisali (2012) etc. applied this approach to estimate technical efficiency in public education production.

The study adopted the stochastic frontier technique for the analysis. This is because unlike DEA, the SFA recognizes the presence of the stochastic error term that affects production process as well as the inefficiency error term (separate noise from efficiency scores).

3.4 Justification of using Technical Efficiency Methodology for the analysis

Technical Efficiency Methodology or stochastic frontier analysis was chosen for several reasons: First, the production process, especially in the primary schools is characterized with stochastic elements (Millimet et al 2004; Muvawala and Hisali 2012; Pascoe and Herrero 2001), so the study gives preference to SFA due to the possibility to account for random shocks. One serious shortcoming of the Data Envelopment Analysis is that it is deterministic, so that a non-stochastic environment is assumed. Given the presence of random shocks that can influence output performance in primary schools, the use of a deterministic methodology is not warranted (Sharma, Sylwester and Margono, 2007). It is significant to note that, the Data Envelopment Analysis neglects the effect of exogenous factors such as the level of economic development and school environment which could be attributed to statistical errors instead of real inefficiency of decision making unit (Grigoli, 2014). This raises the possibility of overestimating the magnitude of inefficiency which could cause problem and uncertainty for policy purposes.

The study had chosen the Technical Efficiency Methodology over the Data Envelopment

Analysis because the DEA does not make a distinction between the environments the primary schools are facing and a school with a harsh environment may be judged inefficient even though its performance may be due to the environment (Johnes, 2004)

The stochastic frontier analysis is employed in this study to analyze the marginal contribution of inputs in the primary schools and responsiveness of the output (standardized test score) to the discretionary inputs (Bravo-Ureta and Pinheiro, 1993). Additionally, the study did not use the DEA because there are no statistical tests to check for the presence of inefficiency (Daghbashyan, 2011).

Again, it is possible to develop measures of *absolute* efficiency with the use of technical efficiency methodology. However, the results from DEA analysis can only portray the relative efficiency among schools, not absolute efficiency of each school (D. et al., 2007).

Furthermore, Technical Efficiency Methodology explicitly assumes that inefficiency affects production, and through frontier techniques, it provides estimates of efficiency scores for each school (Kumbhakar & Lovell, 2000). A growing number of studies estimate technical efficiency of schools applying stochastic frontier methods Barrow, (1991); Deller Rudnicki, (1993); Cooper & Cohn, (1997); Heshmati & Kumbhakar, (1997); Mizala et al. (2002); Sengupta and Sfeir (1986).

Fried et al. (2008) makes it clear that, the higher the quality of the data, the more SFA and DEA generate the same results and that one can apply either of the approaches to estimate technical efficiency. Technical efficiency scores produce by SFA are almost by definition lower than DEA efficiency scores due to the way the frontier is drawn (Johnes et al. 2005; Johnes et al. 2008b). However, in general the two methods should tell the same story, as they both calculate technical efficiency scores by identifying a frontier and comparing the decision-making units to the ones that lie on the frontier, as the benchmark (Haelermans, 2009). To ensure the robustness of the results in efficiency analysis, both technical efficiency methodology and Data Envelopment Analysis were used by most studies (eg Chakraborty et al, 2001; Aaltonen et al, 2006 and Mizala et al, 2002 etc) to analyze schools' efficiency. Results from these studies established that the two main methodologies give a similar ranking of schools in efficiency terms (Mizala Romaguera and Farren, 2002). Smith and Street, (2006) also reported that Data Envelopment Analysis (DEA) and technical efficiency methodology can be applied to measure allocative and technical efficiency in the education sector

3.5 Stochastic Production Frontier and Inefficiency Model

The stochastic frontier estimation method was originally proposed simultaneously by Aigner et al. (1977) and Meeuseen and Van Den Broeck (1977) and it was specified for a cross section as

$Y_i = X_i\beta + (V_i - U_i)$ ……………………………………. (1)

Where Y_i is the output of the ith firm, X_i represents a vector of production input variables for the ith firm, β is a vector of unknown parameters to be estimated. V_i are random variables that estimate errors and exogenous shocks beyond the control of the producer. U_i are non-negative random variables which are assumed to account for technical inefficiency in production. The V_i and U_i are distributed independent of each other.

Following Battase and Coelli (1995), the stochastic error term, V_i is assumed to be independent and identically distributed with mean zero (0) and variance σ^2_v, $N(0, \sigma^2_v)$. The random variable, U_i is also assumed to be truncated normally with variance σ^2_u and the mean, $\mu_i = Z_i\delta_i$

The inefficiency determinant model defines the stochastic inefficiency term as a function of some firm specific factors such that

$U_i = \delta_0 + \sum_j \delta_j Z_j$…………………………………….. (2)

Where Z_j is a set of firm-specific variables which may influence the firm efficiency, δ_j is a vector of unknown parameters.

Two approaches, two-stage and single-stage exist for estimating the inefficiency effect model. With the two-stage process, the stochastic production frontier is initially estimated for each of the firm's technical efficiency. These are then regressed against a number of firm-specific variables, which are assumed to influence the firm's efficiency (Coelli, 2007). While the twostage estimation approach has been identified to be inconsistent with assumptions regarding the independence of the inefficiency effects, it is also econometrically flawed (Pereira and Moreira, 2007); (Kumbhakar and Lovell 2000). According to Battase and Coelli (1995), the two-stage estimation method is not likely to produce estimates which are as robust as those that could be obtained using a single-stage estimation procedure. In this study, the stochastic production frontier and inefficiency function are estimated using single-stage procedure with maximum likelihood estimation method.

The technical efficiency of the *i*(th) school, represented by ZE_i, is defined by the ratio of the mean output for the *i*th school, given the value of the inputs, X_i and its technical inefficiency effect, to the corresponding mean output, given that value of the technical inefficiency of production is zero (Villano and Fleaming, 2004). It is specified as:

$ZE_i = \frac{E(Y_i \backslash U_i, X_i)}{E(Y_i \backslash U_i = 0, X_i)} = e^{-ui}$ ……………………………….. (3)

From equation (3), the technical inefficiency = 1- ZE

The sigma squared and gamma are given by $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ respectively.

The σ^2 indicates the extent at which the functional form specified fits the data and the correctness of the assumptions underlying the distributional form of the composed error term (Crentsil and Essilfie, 2014).

The gamma (γ) tests whether the dominant source of error is not in the deterministic section of the stochastic production function. The numerical value of gamma ranges between 0 and 1. A value of zero shows that all the deviations from the production frontier are attributed to stochastic noise. A value of one also indicates that all deviations are attributed to technical inefficiency. If the value is found between 1 and 0, then the deviation may be attributed to both random and inefficient factors. The explanatory power of the inefficiency in total variation is usually indicated by a high gamma. (Radam et al, 2010). Thus, based on the value of gamma, it is possible to state whether the differences between a schools' output and the frontier output is largely due to random error or sample's inefficient application of resources

The log-likelihood ratio test is performed to establish whether the estimated frontier is efficient. This test indicates the importance of the inefficiency component in the model. The null hypothesis that states that there is no inefficiency in the observed behavior of sampled, H_0: $\mu=0$ is tested against the alternative hypothesis; H_1: $\mu>0$. If the null hypothesis turns to be true, then there is no proof of inefficiency in the sample ($\sigma_u^2 = 0$) and stochastic frontier model changes to an OLS model with normal random errors.

In empirical analysis, three different estimation approaches are used: maximum likelihood techniques, random effects and fixed-effects models (Kumbhakar and Lovell, 2000). Efficiency estimation based on random and fixed effect models have significant drawback (Kokkinou, 2010).

For instance, Simar (1992) had indicated that the fixed effects model seems to produce an inefficient estimation of the slope coefficients and the intercepts of frontier production functions which represent unreasonable measures of technical efficiency. Following similar empirical efficiency works such as Esmaeili (2015); Chakraborty (2009) etc, the stochastic production frontier and the inefficiency models in this study are estimated using the maximum likelihood estimation method to obtain the estimates of parameters which measures the determinants and technical efficiency of the sampled public primary schools in Ashanti Region.

The Cobb-Douglas functional form is selected for this analysis because it is flexible and its returns to scale are easily interpreted (Bravo-Ureta and Evenson, 1994). The Cobb-Douglas frontier model has also resolved the problem of degree of freedom normally associated with trans-log model. Empirically, the Cobb-Douglas production function is widely used by researchers for technical efficiency estimations (Hasssan et al., 2005; Essilfie et al., 2011).

3.6 Data and Model Specification

3.6.1 Sampling Technique

A sample size can be determined with three distinct approaches. These include using a census for small population, imitating a sample size of similar studies and then using formulas to calculate a sample size (Regassa, 2003). This study followed the sample size assumed by the National Educational Assessment (NEA) for performance assessment of primary schools in various Regions of Ghana in 2013. The 2013 NEA sample was essentially a census of all primary schools in Ghana. After exclusion of schools that contained a 3rd grade or 6th grade pupil enrolment less than 10 pupils, the remained schools in the sample frame were then stratified by region and sorted by district, locality (urban or rural), school type and enrolment size. Finally, a sample of forty (40) public primary schools was selected in the Ashanti Region.

This is the sample size that was used for the analysis in this research. According to 2014 National Education Assessment findings report, most performance studies conducted by Research Triangle International (RTI) throughout Sub-Saharan Africa normally rely on a sample of approximately 40 schools and 800 pupils. Careful analysis has shown that this is a sufficiently large sample.

3.6.2 Data Set

The analysis in this study is based on secondary data for 2012/2013 academic year. These data were sourced from National Educational Assessment unit in Accra, Regional and District Education offices in Ashanti Region of Ghana. The selection of the output and inputs variables is carried out in line with existing empirical literature.

The output measure selected for the study is the National Educational Assessment standardized test score in Mathematics and English for primary three and six for 2012/2013 academic year. This national assessment is usually done by Ministry of Education to assess the quality of education at the basic school level (Education sector performance report, 2012). The choice of period was essentially driven by the availability of data on variable of interest. The National Educational Assessment started since 2011; however the data used for the analysis is focused only on 2013 mainly because there was no data across different years.

Although other set of outputs such as dropout and enrollment rates Kanep (2004) were used in the literature, this study considered the standardized test score as an appropriate output for an efficiency analysis on primary education. Hanushek (1986) argues that estimation of the education output as cognitive knowledge measured by standardized test scores would be most appropriate for basic and perhaps senior high schools, but it would be very erroneous to estimate the output of higher education in the same way.

The school and teacher input variables associated with pupils' achievement employed in this study included the following: pupil teacher ratio, number of classrooms, percentage of teachers with at least diploma in education and percentage of teachers with at least 10 years of teaching experience.

The ratio of pupils to teaching staff (pupil-teacher ratio) is very important input because it indicates how efficient the education system is and the level of resources devoted to education. It is calculated by dividing the number of pupils at a given level of education by the number of teachers. A low pupil-teacher-ratio enables the teacher to allocate more time to each pupil, hence improving performance, all things being equal. Smaller pupil-teacher ratio generally allowed teachers to spend more time with each pupil in the classroom and relatively less instructional time in classroom management. This provides better activity-based learning to the pupils and ensures higher performance, all things being equal.

Number of classroom is used as a proxy of capital, since it captures the availability of basic facilities, as this can be a binding constraint in developing countries. Only classes in permanent structure condition were considered in our analysis. Those in temporary structure condition were excluded.

The variables such as percentage of teachers with at least diploma in education and percentage of teachers with at least 10 years of teaching experience measure teachers' quality. Economic theories predict that the use of higher quality inputs result in output growth, ceteris paribus (Adkins and Moomaw, 2005). Hence, a teacher with advanced degree or diploma and additional experience is expected to improve pupil academic performance. A finding from the OECD courses for International Student Assessment (PISA) argues that systems prioritizing higher teacher quality over smaller classes tend to perform better. This ratifies other research findings that concluded that raising teacher quality is a more effective measure to improve pupils' performance.

The variables that are expected to control the socioeconomic conditions of the pupils are: percentage of pupils with disabilities and percentage of pupils benefiting from the free feeding programme, a proxy for poverty. According to Martens (2007), the main objective of the Ghana's school feeding programme was to reduce poverty, hunger and malnutrition among children of public primary schools that are located in the poor and deprived districts that experience food insecurity. Besides, other empirical studies such as Chakraborty (2009) that investigated technical efficiency in Kansas school districts in USA, used free lunch as a proxy for poverty. Studies such as Chakraborty (2009) and Hanushek (1986) find a significant influence of these socioeconomic factors on students' achievement.

Apart from examining the presence of inefficiency in the public primary school system, the study also employs the inefficiency affect model to identify various school-specific variables that affect technical efficiency of the schools.

While input variables under the control of the school administration are used in the stochastic production function to estimate the efficiency levels of the schools, the socioeconomic and environmental input variables are also used in the inefficiency effect function to determine the factors that affect the efficiency of the schools.

3.6.3 Educational Production Function

The first step to assess school performance using SFA is to specify a production function. The theoretical framework employed in the efficiency analysis of education production assumes the form of a production function, that is, the relationship between the set of relevant inputs and output. In this relationship, producers obtain the highest output attainable from a given level of inputs. Such a relation defines the production possibility frontier

The educational institution is similar to a firm that transforms inputs into outputs through a production process. The education production function relates observed pupils outcomes to characteristics of the pupils, teachers and other pupils in the school as well as other school characteristics (Kirjavainen, 2009). Typically, input variables in the education production function include the school environment and teaching characteristics, while outputs are generally measured in terms of pupils' test scores for the basic and senior high categories (Chakraborty, 2009). Nevertheless, the literature has also shown that output could be measured either by the number of student graduating per year or student success in securing admission into the tertiary institutions.

The schools use various inputs that are connected with instructional and non-instructional activities in education production. These inputs may fall within and outside the control of the school management. Educational inputs which are usually connected with test scores are usually measured as pupil-teacher ratio, the number of classrooms, teaching experience, and other instructional and non-instructional spending (Chakraborty, Biswas and Lewis, 1999). Non-school inputs (inputs outside decision making power of schools) including the socioeconomic status of the pupils and other factors such as parental education and the family's financial background influence pupils' productivity (Hanushek, 1986; Grosskopf and Weber, 1989). According to Chakraborty (2009), the environmental factors are usually captured by geographical location of the school (e.g., rural or urban).

3.6.4 Model Specification

For the analysis of technical efficiency and assuming a Cobb–Douglas functional form, the stochastic production function adopted for this study is specified as

$$lnY_i = \beta_0 + \sum_{j=1}^{4} \beta_j \, lnX_{ji} + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where i represents the i(th) school (i = 1, 2, …, 40), Y_i is the output of the i(th) school, and X_{ji} represents the input j required by the i(th) school, β_j are parameters to be estimated.

From equation (4), the output of the public primary school is expressed as a function of pupil teacher ratio, number of classrooms, percentage of teachers with at least diploma in education and percentage of teachers with at least 10 years of teaching experience and is estimated by;

$$lnY_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, Yi = standardized test scores in Mathematics and English language of the *i*th school

X_{1i} = pupil teacher ratio in the *i*th school

X_{2i} = number of classrooms in the *i*th school

X_{3i} = percentage of teachers with least diploma in education in the *i*th school

X_{4i} = percentage of teachers with at least 10 years of teaching experience in the *i*th school

The second stage of the analysis is the investigation of the school-specific factors that explain public primary school efficiency variation. In this research, the stochastic production and inefficiency functions were estimated simultaneously to avoid the inconsistencies associated with the two-stage estimation approach.

The technical inefficiency model is specified as

$$U_i = \delta_0 + \delta_1 DIS + \delta_2 POV + \delta_3 LOC + W \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(6)}$$

U_i represents the efficiency distribution for the *i*th school. W is the disturbance term. DIS represents percentage of students with disabilities in the *i*th school, POV (proxy for poverty) represents percentage of pupils benefiting from the free feeding in the *i*th school, and LOC is a dummy, capturing the effects of geographical location of *i*th school on efficiency of individual school, it has value of 1 if urban, otherwise 0.

According to the literature, socioeconomic and environmental factors such as disability of pupils, free lunch (proxy for poverty) and geographical location of the school are expected to affect the technical efficiency levels of sampled primary schools in Ashanti region.

The table 1 shows the variables with their corresponding expected signs. Number of classrooms, percentage of teachers with at least diploma in education and percentage of teachers with at least 10 years of teaching experience are expected to have positive effect on standardized test score.

However pupil-teacher ratio is expected to have negative effect on standardized test score. Additionally, percentage of students with disabilities and percentage of pupils benefiting from the free feeding (proxy for poverty) are expected to have a positive effect on technical inefficiency while geographical location of a school could either affect technical inefficiency positive or negative, in accordance with what is in the literature.

Table 1: Summary of variables used in the study and their hypothesized signs

Relevant inputs of the production function of the school		
Variables	Description	Hypothesized signs
X_1	pupil teacher ratio	-
X_2	Number of classrooms	+
X_3	percentage of teachers with least diploma in education	+
X_4	percentage of teachers with at least 10 years of teaching experience	+
Variables affecting school inefficiency		
DIS	Percentage of pupils with disabilities	+
POV	Percentage of pupils benefiting from free feeding (proxy for poverty)	+
LOC	Geographical location (rural or urban): A dummy variable which takes a value of 1 if school is urban.	+ /-

3.7 Assumptions and Estimation method

According to Aigner et al (1977), it is assumed that V_i is a random error with zero mean and it is related with random factors such as measurement errors in production and it is assumed to be independently and identically distributed as $V_i \approx iid\ N\ (0,\ \sigma_v^2)$. U_i is assumed to be non-negative random variable, truncated half normal, independently and identically distributed as $U_i \approx iid\ N\ (0, \sigma_u^2)$ and associated with school specific factors which lead to the *i*th school not attaining maximum efficiency of output.

The single-stage maximum likelihood estimation method is used to estimate the technical efficiency and its determinants simultaneously.

3.8 Statistical significance tests

The t-test was used to test for the statistical significance of the parameters of both stochastic production and efficiency effect functions at one percent (1%), five percent (5%) and ten percent (10%) level of significance. The mixed chi-square test is used to test for the statistical significance of the central hypothesis of the study.

3.9 Tools for Data Analysis

A computer program, Frontier 4.1c version developed by Coelli (1996) was used to estimate both the stochastic frontier function and the technical efficiency levels. It was also used to identify the significant determinants of the technical efficiency in the sampled primary schools in the study area.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the empirical results and the analysis of the study. Critical analysis is made on the results consisting of test of hypothesis, stochastic production estimates and the technical efficiency scores of sampled public primary schools. Discussion on determinant of technical inefficiency is also done here.

Table 2 contains a summary statistics of the output and input variables used in the study. The table indicates the mean, minimum, maximum and standard deviation scores of the output and inputs such as pupil-teacher ratio, number of classrooms, percentage of teachers with diploma or degree and percentage of teachers with ten or above years of experience.

Table 2: Descriptive statistics used in the study

Variables	Mean	Standard deviation	Minimum	Maximum
Output (Y)				
3rd grade English test score	33.070	6.4490	21.71	37.90
3rd grade Maths test score	28.9002	4.1757	20.63	48.98
6th grade English test score	31.2075	4.1741	19.2	45.89
6th grade Maths test score	32.5110	6.2677	24.58	41.73
Inputs (X)				
Pupil-teacher ratio	7.1	2.2847	11	54.67
Number of Classrooms	27.6175	11.3296	3	13
Teachers with Diploma or degree (%)	76.0467	26.0201	0.00	100.00
Teachers with ten or above years of experience (%)	47.8166	16.2436	0.00	100.00

4.2 Cobb Douglas Stochastic Production Estimates

The Cobb Douglas stochastic production function is estimated using the maximum likelihood method with standardized test scores as endogenous variable and pupil-teacher ratio, number of classrooms, teacher's experience and teacher's level of education as exogenous variables. The results of the estimated stochastic production parameters are presented in table 3

Except for the number of classroom, all the coefficients have their expected signs but only the coefficients of pupil-teacher ratio and teacher's experience are statistically significant at 95% confidence level. The elasticity for all input parameters is less than one, implying that a unit change in the inputs of each coefficient would cause a less than proportionate increase in the standardized test score.

Pupil-teacher ratio was found to have negative and significant influence on pupils' performance. The coefficient on the pupil-teacher ratio implies that a unit increase in pupil-teacher ratio will cause a fall in standardized test score by 0.097% assuming that other variables are held constant. This implies that, large pupil-teacher ratio is associated with poor performance and smaller classes are more conducive for better learning. Smaller pupil-teacher ratio generally allows a teacher to spend more time with each pupil in the classroom and relatively less instructional time in classroom management. This provides better activity-based learning to the pupils and ensures higher performance, all things being equal. This finding agrees with the results of Glass and Smith (1978) which showed that ''as pupil-teacher ratio increases, achievement decreases''.

Teachers' experience also has positive and significant impact on pupil's performance. Given that all factors are the same, a 1% increase in teacher's experience will cause standardized test score to increase by 0.165%. This implies that the greater the number of years of teachers teaching experience in the school the higher impact they make on pupils performance. Teachers acquire a whole lot of experiences from the classroom, workshops, seminars and in-service training as their years of teaching increases. The experience they acquire improves their teaching skills for effective delivery. Researchers have found that "experience improves teaching skills" while "students' tend to learn better at the hands of a teacher who has taught them continuously for a number of years" (Waiching, 1994; McClelland, 1995).

Although, the teachers' level of education is not significantly different from zero, the positive coefficient on it implies positive contribution to pupil learning process. All things being equal, a 1% increase in teachers' level of education would insignificantly increase standardized test score. This can be attributed to the fact that some primary school teachers in the study area most at times pursue higher courses which do not march the educational needs of the pupils. The result also suggests that, effective teaching and learning in the primary school does not depend entirely on higher academic qualification of teachers. This result confirms previous findings in the literature particularly Chakraborty (2009), where teacher's level of education was found to have insignificant impact on academic performance.

The number of classrooms was found to have negative and insignificant influence on academic performance. The result shows that number of permanent classrooms does not explain the variations in performance of pupils. This may be explained by the fact that temporary classrooms or structures can be erected in absence of permanent classrooms for effective teaching and learning to occur.

Table 3: Maximum likelihood Estimates of Parameters of Stochastic Production

Variable	Parameter	Coefficient	Standard error	t-value
Constant	β_0	3.308 ***	0.231	14.281

ln(Pupil-teacher ratio)	β_1	-0.097 **	0.051	-1.878
ln(No of classrooms)	β_2	-0.073	0.080	-0.921
ln(Level of teacher education)	β_3	0.009	0.023	0.420
ln(Teachers' experience)	β_4	0.165 ***	0.046	3.595
Variance Parameters				
Sigma squared	σ^2	0.438 ***	0.150	2.916
Gamma	γ	0.982 ***	0.011	84.551
Log likelihood function	*LLF*	17.086		
LR test of the one-sided error		29.034		

***Significant at 1%, ** significant at 5%, * significant at 10%

The likelihood ratio test of the one-sided error of 29.03 is statistically significant at 5% level when compared with a critical value of 2.706 (Kodde and psalm, 1986). This test result clearly showed the rejection of the null hypothesis for the alternative hypothesis of the existence of inefficiency in the sampled public primary schools

The variance parameters of the stochastic production function are statistically significant at one percent. The estimated sigma-squared value of 0.438 is significantly different from zero, showing a good fit of the Cobb Douglas model for the data and appropriateness of the specified distributional assumptions of the composed error term. The parameter, gamma, also measures the percentage of total variance in the combined error attributable to inefficiency. In this study, the gamma was estimated at 0.982 and significantly different from zero. This indicates that about 98.2% of the total variation in public primary schools performance is due to the presence of inefficiency. The result of the diagnostic statistics clearly confirmed the significance of the stochastic parametric production function and the maximum likelihood estimation model employed.

4.3 Estimation of School level Technical Efficiency

The result of the frequency distribution of technical efficiency of the public primary schools is presented in table 4 based on the estimates of the frontier function. From the analysis, it was observed that the technical efficiencies range from a minimum of 34.3% to maximum of 97.0%. The mean technical efficiency score is estimated to be 86.9%. This implies that, on average public primary schools in the region are able to produce about 86.9% of potential output (learning outcome) from a given production inputs. It follows that on average about 13.1% of output has been lost through inefficiency. The mean efficiency score tells us that the level of primary schools output can be increased if appropriate measures are taken to improve their level of efficiency.

The analysis again shows that 75% of the sampled public primary schools are operating above the overall mean technical efficiency while 25% are also producing at the technical efficiency level below the mean. Additionally, the frequency distribution of the technical efficiencies showed that 55% of the sampled primary schools were operating within the efficiency score of 90-99 percent, 32.5% of the sampled primary schools are also within the efficiency score of 8089 percent, 5% within the efficiency score of 70-79 percent, and 2.5% are operating within 5059, 40-49 and 30-39 percentages.

Table 4: Frequency distribution of technical efficiency levels of sampled primary schools

Efficiency scores (%)	Frequency	percent (%)	Cum. distribution

30-39	1	2.5	2.5
40-49	1	2.5	5
50-59	1	2.5	7.5
70-79	2	5.0	12.5
80-89	13	32.5	45
90-99	22	55.0	100
Mean	86.9		
Maximum	97.0		
Minimum	34.3		
Range	62.7		
Standard deviation	98.9		

4.4 Determinants of Technical Efficiency in Public Primary School

The table 5 shows the maximum likelihood estimate of determinants that influence technical efficiency of public primary schools in the study area. All the three factors estimated in the inefficiency model had their expected signs. Poverty and geographical location (urban) of a school were found to be statistically significant at 5% level. However, pupil with disability was found to be statistically insignificant.

The study showed that poverty is a major determinant of technical efficiency with positive influence on technical inefficiency. This implies that primary schools are more likely to be technical inefficient if large proportion of their school population come from impoverished families. This is because pupils from financially poor families are likely to be undernourished or starved. The nutrition status of the child is very important; its deficiency can hinder proper development of the brain leading to poor thinking ability. Unhealthy pupils are more likely to absent themselves from school because of sickness. Additionally, pupils from poor households may not be punctual and regular at school because conditions at home may compel them to combine work with school. Irregular attendance at school can negatively affect the pupils' ability to understand lessons and thus affect academic performance. This finding conformed to Chakraborty (2009) finding that established a positive correlation between poverty and technical inefficiency.

The coefficient on the dummy variable, geographical location (urban) is negatively related to technical inefficiency and significantly different from zero. The negative sign supports the argument that urban public primary schools are more efficient than the rural public primary schools. The schools in the rural areas are less efficient because they lack most of the essential educational resources such as experienced trained teachers, infrastructure and instructional materials that make teaching and learning effective. Additionally, most parents of pupils in the urban primary schools are more educated and relatively well-off than their counterparts in the rural areas and therefore they are able to provide their children with all the resources and encouragement that they need to learn at school. Besides, pupils in the rural areas felt no pressure to attain good performance because the expectation of their parents towards education is low. This finding is consistent with literature and expectation of the study.

Though, pupil with disability is positively signed, it is not statistically significant. The result shows that pupil with disability does not explain the variations in technical efficiency of public primary school. It also suggests that pupils' disabilities do not affect their ability to performance at school. This result is consistent with finding of Chakraborty (2009) which reported positive and insignificant influence of pupil's disability on technical inefficiency.

Table 5: Estimates of Determinant of Technical Inefficiency in Public Primary Schools

Variable	Parameter	Coefficient	Standard error	t-value
Constant	δ_0	-3.270 **	1.668	-1.960
Disability (DIS)	δ_1	0.113	0.129	0.880
Poverty (POV)	δ_2	0.019 **	0.009	1.982
Location (LOC)	δ_3	-1.920**	1.000	-1.920

*** Significant at 1%, ** significant at 5%, * significant at10%

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of the finding, conclusions and recommendations based on the study. It also contains a section that highlights on directions for further studies and the limitation of the study.

5.2 Summary of the Finding

According to the study, the overall mean technical efficiency of the sampled public primary schools in the Ashanti region is 86.9%. This implies that, there was underperformance of about 13.1% which could be attributed to inefficiency. The study showed that 25% of the sampled public primary schools are operating below the overall mean technical efficiency whilst 75% of the schools are also operating above it. Again, technical efficiency of the schools ranges from a minimum of 32.4% to a maximum of 97.0%.

Secondly, hypothesis test conducted proves the presence of inefficiency in the sampled public primary school in the study area.

The gamma (γ) is estimated at 0.982. This implies that about 98.2% of the total variation in the performance of the primary schools is attributed to technical inefficiencies and only 1.8% of the total variation is due to random shocks outside the schools control. The high gamma value indicates that the variation in total output were largely as a result of technical inefficiency (Radam et al, 2010).

The study has proven that academic performance in the primary school responds negatively to pupil-teacher ratio and positively to teacher's level of experience. This result indicates that, pupil-teacher ratio and teacher's experience are very important determinants of academic performance at the primary schools.

The study also found poverty and geographical location of a school to be the major determinants of technical efficiency of basic primary schools in the study area.

5.3 Conclusions

The main objective of the study was to analyze technical efficiency and its determinants of the sampled public primary schools in the Ashanti Region of Ghana. The analysis involves one-step estimation of Cobb-Douglas stochastic frontier and inefficiency models. Based on the findings of the study, the following conclusions were reached:

The technical efficiency of the sampled public primary schools is less than one, indicating that the schools are producing below the production frontier and are therefore technically inefficient. The mean technical efficiency estimate of 86.9% suggests that public primary schools could increase their performance by 13.1% using the same level of inputs and existing methodologies.

The study showed that, pupil-teacher ratio and teacher's experience have significant effect on the academic performance of pupils in the public primary schools. Finding of the study also indicated that teachers' level of education has positive but insignificant influence on academic performance at the primary school.

With the returns to scale value less than one, public primary schools in the region can be described as exhibiting decreasing returns to scale.

Socioeconomic and environmental factors such as poverty and geographical location of a school have been found to be important determinants of technical inefficiency in basic education production. This revelation confirms findings of the literature which points out that socioeconomic factors have strong effect on technical efficiency of schools.

5.4 Recommendations

Careful studies of the findings suggest that, quality education requires much commitment from dedicated teachers, motivated students and parents, as well as a committed government. Based on the conclusions drawn from this study, the following recommendations should be noted.

The introduction of free education in the basic school level has exerted much pressure on both teacher resource and classrooms resulting to high pupil-teacher ratio (PTR). To improve academic performance of pupils, policy makers should pay more attention on how to lower the pupil-teacher ratio in public primary schools.

Government should intensify efforts at retaining and developing the teaching staff of the primary schools since teaching experience have been found to be a significant predictor of pupil's performance. Seminars, workshops and in-service training should also be organized for teachers in order to acquaint them with the modern methods and skills of teaching.

Government should provide adequate school infrastructure, instructional materials and experienced teachers to the primary schools that are located in the rural areas to improve their level of efficiency. Besides that, government should try to provide a financial support to the pupils that live in rural areas where poverty is severe.

Although parents in the rural areas have less education and financial support for their children, they can help their children performance in terms of giving them moral support and encouragement to study hard. Parents of pupils should always monitor and ask their wards of their learning progress at school.

Teachers in the rural areas should encourage the pupils to study hard and help them to complete most of their work at the school during studying time because their parents who are less educated might not be able to assist them if they do the work at home.

Lastly, teachers should create good relationship with pupils in the primary schools. This can improve performance because when teachers are close to pupils, pupils will feel easy and not shy to ask anything that they do not understand.

5.4.1 Direction for Further Studies

This study focused on public primary school technical efficiency for a given year. The study recommends that future research should analyze the efficiency differences over time using panel data. Further research and data are needed to fully explore the educational efficiency.

Also, studies should be extended to other estimation methods in addition to the stochastic frontier analysis so as to compare and contrast results from other methods.

5.5 Limitation of the study

There is major challenge of data collection as educational data on both inputs and output are not readily available. Data on National Education Assessment (NEA) which serves as the only standardized test score for the primary schools could not be accessed across time periods.

Many important socioeconomic factors affecting technical efficiency of primary schools are not observed and/or quantifiable, and ultimately are difficult to incorporate mechanically into the inefficiency model. For instance, parents' educational background and innate endowments of pupils are difficult to be measured.

It was costly and time consuming to move to national educational assessment office in Accra and various District, Municipal and Metropolitan education offices in the region in search of data. It can therefore be concluded that, time and financial constraints had affected early completion of this work.

REFERENCES

Adeyemi (2012). School Variables and Internal Efficiency of Secondary Schools in Ondo State, Nigeria. *Journal of Educational and Social Research*

Adeyemi and Adu (2012). Teachers' Quality and Internal Efficiency in Primary Schools in Ekiti State, Nigeria. *International Journal of Academic Research in Progressive Education and Development. Vol. 1,*

Adkins, L.C. and R.L. Moomaw (2003). "The Impact of Local Funding on the Technical Efficiency of Oklahoma Schools," Economics Letters, forthcoming

Adu, E.T. (2010). "School-based variables and internal efficiency of colleges of education in Nigeria" Unpublished PhD Thesis, University of Ado Ekiti, Nigeria.125-147

Aigner, D. J., Lovell, C. A. K. & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6, 21-37.

Andrew (2001). An Empirical Survey of Frontier Efficiency Measurement Techniques in Education. Education Economics 9(3):pp. 245-268

Aristovnik (2011). Analyzed efficiency of education spending in central and Eastern Europe. *Management knowledge and Learning, International conference, 2011.*

Battese and Coelli (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics 38 ; 387-399*.

Battese G. E & Coelli. T. J. (1992). Frontier production functions, technical efficiency, and panel data with application to paddy farmers in India, *Journal of Productivity Analysis*.

Battese, G. E. And Coelli, T. J. (1993). A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects, *Working Papers in Econometrics and Applied Statistics, No.69, Department of Econometrics, University of New England.*

Battese, G.E. and Coelli, T.J. (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data, *Empirical Economics*, vol. 20, no. 2, pp. 325-332.

Barbetta and Turati (2001). Efficiency of Junior High Schools and the Role of Proprietary Structure

Bowles (1970). Towards An Educational Production Function

Barrow, M. N. (1991). Measuring Local Education Authority Performance: A Frontier Approach. *Economics of Education Review* 10: 19-27

Bravo- Ureta and Evenson (1994). Efficiency in agricultural production: The case of peasant farmers in Eastern Paraguay. Agricultural Economics 10: 27–37.

CEPA (2000). Basic Education in the Post-Reform Period

Chakraborty (2009). Efficiency in public education: The role of socioeconomic variables *Research in Applied Economics*

Chakraborty, K.Biswas, B., & Lewis, W. C. (2001). Measurement of technical efficiency in public education: A stochastic and nonstochastic production function approach. *Southern Economic Journal*, 67(4), 889-905

Coelli, T. J. (1996). 'A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation.' CEPA Working Papers 7/96

Coelli, T. (1995). “Estimators and Hypothesis Tests for a Stochastic Frontier Function: A Monte Carlo Analysis,” *Journal of Productivity Analysis*, vol. 6, pp. 247-268.

Coleman, J., Campbell, E., Hobson, C., Mcpartland, J., Mood, A., & Weinfeld, F. (1966). Equality of educational opportunity. Washing-ton, DC: National Center for Educational Statistics.

Crentsil and Essilfie (2014). Measurement of technical efficiency of smallholder fish production in Ghana: A stochastic frontier approach. *Journal of Development and Agricultural Economics*

D. ET AL. (2007). Performance Indicators for Public Spending Efficiency in Primary and Secondary Education

Ergulen and Torun (2009). *Technical efficiency across high schools in Nigde province of Turkey*. *Journal of Applied Science* 9(9): 1733-1739

Esmaeili (2015). Technical efficiency analysis for the Iranian fishery in the Persian Gulf. *ICES Journal of Marine Science.*

Farrell, M.J. (1957). The Measurement of Productive Efficiency. Journal of the Royal Statistical Society. Series A (General), vol. 120, no. 3, pp. 253-290.

Forsund, E. R., C. A. K. Lovell, & Schmidt, P. (1980). A survey of frontier production functions and their relationship to efficiency measurement. *Journal of Econometrics* 13:5-25.

Franta, Prague And Konečny (2009). Stochastic Frontier Analysis of the Efficiency of Czech Grammar Schools. *Czech Sociological Review*, Vol. 45, No. 6: 1265–1282

Fried, H. O., Lovell, C. A. K., & Schmidt, S. S. (2008). The measurement of productive efficiency and productivity growth. *New York: Oxford University Press*.

George E. Battase and Tim J. Coelli (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics 38: 387-399*

Glass,V.& Smith, L. (1978). Meta-Analysis of Research on the Relationship of Class Size and Achievement, San Francisco, CA*: Far West Laboratory for Educational Research and Development*

GNECC (2014) .National Education Sector Annual Review 2014

Grosskopf, S., and W. Weber (1989). "Measuring School District Performance." Public Finance Quarterly 17:409-29.

Grosskopf, S., K.J. Hayes, L.R. Taylor, & Weber, W. L, (1997). Budget-constrained frontier measures of fiscal equality and efficiency in schooling, *Review of Economics and Statistics*

Haelermans (2009). A meta-regression analysis of education efficiency scores. *Tier Working Paper Series.*

Hanley, N and Spash, C.L, (1993). Farm management Research for small farmer Development, Food and Agriculture Organization of the United Nations, Rome

Hanushek, E. (1979). "Conceptual and empirical issues in the estimation of educational production functions", *Journal of Human Resources* 14 (3), 351-388

Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public Schools, *Journal of Economic Literature*, 24, pp.1141-77.

Hanuskeke. E. A. (1986). The Impact of Differentiate Expenditure on School Performance.

Educational Research. Vol.18, No.4, 45-62

Jondrow, Lovell, Materon and Schmidt (1982). On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model. *Journal of Econometric 19: 233-238*

Kanep, H. (2004). "Assessing the efficiency of Estonian secondary schools: an application of data envelopment analysis", *Working paper*, University of Tartu.

Kirjavainen, T., & Loikkanen, H. A. (1998). Efficiency differences of Finnish senior secondary schools: An application of DEA and Tobit analysis, *Economics of Education Review*,

Kodde, D.A. and F.C. Palm (1986). Wald criteria for jointly testing equality and inequality restrictions, *Econometrics* 54: 1243–1248.

Kumbhakar, S. C., & Lovell, C. A. K. (2000) *Stochastic Frontier Analysis*. New York, NY: *Cambridge University Press.*

Levin, H. (1974). "Measuring Efficiency in Educational Production." Public Finance Quarterly 2:3-24.

Martens (2007). Impact of the Ghana School Feeding Programme in 4 districts in Central Region, Ghana

Mastromarco (2008). Stochastic frontier models: Department of Economics and Mathematics-Statistics:

Meeusen W & Van De Broeck J, (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* 18: 21–37

Ministry of Education (2012). *Education Sector Performance Report*

Ministry Of Education’s Basic Report, 2012/2013. Ministry of Education, Research and Statistics Department

Mohd Arshad (2012). Estimations of Educational Production Functions and Technical Efficiency of Public Primary Schools in Tasmania. Unpublished MA Thesis

Muvawala1 and Hisali (2012). Technical efficiency in Uganda’s primary education system: Panel data evidence. *The African Statistical Journal,*

National Education Assessment Technical Report, (2013)

Pereira ET AL, (2007). Efficiency of Secondary Schools In Portugal: A Stochastic Frontier Analysis

Radam, A., Yacob, R. M., Muslim, M. F. H. (2010). Technical Efficiency of the Malaysian Wooden Furniture Industry: A Stochastic Frontier Production Approach. *International Business Research, Vol. 3, No. 3.*

Regassa (2003). *Technical efficiency variation for smallholders irrigated maize producers*. Unpublished MA Thesis, Mekette University College of Business and Economics, Ethiopia.125147

Salim (2006). Measuring Productive Efficiency Incorporating Firms’ Heterogeneity: An Empirical Analysis. Journal of Economic Development

State University (2014). *Inputs and Outputs choices in education*: http://education. State university.com (accessed November 12, 2014)

Sutherland, Price and Gonand, (2009). Improving Public Spending Efficiency in Primary and Secondary Education. OECD *Journal: Economic Studies.*

Waiching, E. M. (1994). "Reflecting on reflections: A case study of experienced and inexperienced ESL teachers" System 22 (1) Pergamon Elsevier Science Ltd. 93.

Waldman (1984). Properties of Technical Efficiency Estimators in the Stochastic Frontier Model. *Journal of Econometrics 25: 353-364.*

Webbink (2012). *Efficiency in Education*. Erasmus School of Economics, University of Rotterdam.

APPENDIX

Efficiency Levels of Each Public Primary School

Number of schools	Technical Efficiency
1	0.90102271
2	0.93620677
3	0.89045895
4	0.88662122
5	0.95666393
6	0.77154228
7	0.89686067
8	0.87306546
9	0.97082401
10	0.43239106
11	0.95837242
12	0.90055758
13	0.73829668
14	0.86503556
15	0.88970491
16	0.56084991
17	0.94209821
18	0.95626572
19	0.96235476
20	0.89757397
21	0.91977600
22	0.92335937
23	0.92653075

24	0.85528015
25	0.34323850
26	0.96733788
27	0.93706578
28	0.82550166
29	0.80601935
30	0.88845150
31	0.90725067
32	0.92682613
33	0.96693241
34	0.90803919
35	0.93476166
36	0.95112681
37	0.86016899
38	0.88869201
39	0.9234839
40	0.91961388