Measuring School Efficiency: The Contemporary Understanding

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Abstract

Evaluation of efficiency of educational unit has become an important priority for many policy makers. A current approach considers the school as a production unit that uses multiple inputs to produce multiple outputs. This paper examines the approaches to measuring efficiency in schools. It critically assesses efficiency from inputs and outputs measures. In the context of the paper approaches to estimating efficiency is classified into two as parametric and non-parametric (regression based) techniques. While the former involves the characterization of the functional forms, the latter makes a linear programming approach to efficiency measurement. Based on this premise, the paper identifies cost and production functions as parametric approach to efficiency measurement while Data Envelopment Analysis (DEA) is identified as a non-parametric approach to estimating school efficiency. The paper recommends the needs for educational administrators and researchers to acquaint themselves with the inputs and outputs of education process for proper management to achieve efficiency and effectiveness in the school system.

Introduction

In the recent years the expectations of the public about the efficiency of schools has been on the increase. The public want to know the extent to which the resources available to schools have been utilized for the achievement of the objectives for which schools were established. In view of this, the resources available to schools are of paramount importance to the success of any school. These resources must be available at the right time, in the right quantity and quality. Schools utilize large amount of a country's available resources and how they do this affects the entire population. Therefore, schools must strive hard to minimize waste in resource utilization and produce high quality outputs.

The debate over cost-effectiveness of secondary schools is sparked by the public's desire for increased accountability and efficiency in public education. Tax payers want to know how their money is being spent, and whether additional funds are justified. Researchers hold divergent opinions on education cost and goal achievement in education. While some argued that dramatic increase in cost over recent decades has brought little or no advancement in student achievement, others such as Hanushek (1986) are more optimistic, claiming that some expenditure is tied to improve students' achievement. Experts such as Riew (1986) do agree that research should examine how funds are actually spent and

school must discover more cost-effective ways to allocated and utilize resources. The main purpose of school evaluation is the definition of the factors that reflect the performance of the school. A current approach to school evaluation considers the school as a production unit that uses multiple resources and produces multiple outputs (Maragos and Depotis, 2001).

School efficiency can be measured using various measures as identified by scholars such as Adeyemi (1998) who opined that school efficiency can be measured using the inputs and outputs available to the school. In the contemporary economics of education studies, a number of approaches had been designed to measure the efficiency of schools. These approaches see the school as a production unit which uses multiple inputs to produce multiple outputs, as against a traditional measure where the number of student-year used to complete a level of education is used to determine an efficient school. The objective of this paper is to present modern approaches to quantitatively measuring school efficiency and to examine its appropriateness in the education industry.

The Concept of Efficiency

Efficiency in education is viewed as the ability of the educational system to turn out its outputs with minimal wastage. In this context, efficiency refers to the extent to which educational system reduces wastage in the use of its resources. It is therefore, an important measure of educational system's performance. Measures of efficiency are based on the estimates of the degree to which the school concerned could have secured more output for its input levels or the degree to which it could have used less input for its output level (Thanassoulis, 2001). A school system is said to be efficient if maximum output is obtained from a given input or if a given output is obtained with minimum possible input. Inputs and outputs have to be somehow valued so that they may be aggregated, and usually prices are used to perform this valuation function. The problem of measuring efficiency of school is however considered and it mainly stems from the difficulties in measuring school output as well as quantifying the relationship between input and outputs. How school output id measured depends on the philosophical, political or analytical view point adopted, while the objective may differ considerably.

According to Thanassoulis (2001), school efficiency can be examined from two perspectives: these are outputs and inputs measures. The measure of output efficiency reflects the extent to which the output levels of the school concerned can be raised through improved performance and no additional resources while maintaining its output mix (i.e. radial output expansion). The measure of input efficiency reflects the extent to which the input level of the school concerned can be lowered through improved performance and no output reduction while maintaining input levels are to each other, while the output mix of a school is reflected in the ratio of its output levels are to each other.

In the real sense the measure of efficiency relies on estimating maximum output levels for a given input level or alternatively, maximum input level for a given output level. Olivera (2005) examined educational efficiency from two components. These are economic and social components. The economic components have to do with synthesis and yield, that is, a reflection of the money used to get result, which means efficiency from economic point of view is to predict the probability and the extent of financial profit (how much money will cost to get a degree and will this investment return and how long will it take to return?). In this situation, educational efficiency has a similar significance to cost-effectiveness and thus the institutional goal is to achieve aim with less money or to solve many tasks (outputs) as possible with given money (inputs). The social effects of efficiency can be seen from micro and macro levels. At macro level, the social effects of efficiency can be evaluated by educational level of the population, the labour market position of the graduates, scientific knowledge of the university graduates and their lecturers and by change in the demand for higher education. At the micro level, it must evaluate interest in the given institution by the number of people that want to be admitted and by the level of sacrifices that families and employers are set to achieve a higher education.

Approaches to Measuring Efficiency

Broadly speaking, there are two general types of techniques namely: parametric or regression-based technique and non-parametric or linear programming-based technique. While the primary objective of the two techniques is to measure and quantify efficiency, they are fundamentally different in their construction and underlying assumptions. This is because each of the techniques possesses its own strength and a weakness while neither is generally regarded to be superior to the other (Salerno. 2001).

Stochastic Frontier Analysis (SFA) is a parametric technique which provides an estimate of efficiency. In other words, the parameter of a model is first specified and then estimated using real or simulated data. Data Envelopment Analysis (DEA) is a non-parametric approach for estimating efficiency which relies on linear programming. That is, rather than estimate values for selected parameters, the non-parametric approach relies on linear-programming in form of mathematical programming to characterize the set of efficient producers and then derived estimate of efficiency for inefficient observation based on how far they deviate from the most efficient ones (Salerno, 2001).

Production Function

The school system is impacted by various school and non-school inputs to produce multiple outputs that are assumed to be measurable by students' academic performance. The purpose of education is to transmit knowledge and

develop students' basic cognitive, affective and psychomotor skills. These skills are measured in standardized tests such as the Senior School Certificate Examination (SSCE) conducted by both the West Africa Examination Council (WAEC) and National Examination Council (NECO) in the Nigeria Secondary School System.

The relationship between the amount of input required and the amount of output that can be obtained is called the production function. The production function specifies the maximum amount of output that can be produced with a given quantity of inputs. This mathematical construction, that is, the production function depicts the maximum amount of outputs that can be produced by a school from using different combination of inputs (Nicholson, 1995).

In the field of higher education, education production literature reveals widespread support for the view that production process of universities is largely unknown (Salerno, 2001). In one of the most thorough surveys of higher education production process, Hopkins (1990) reviews over 30 studies and summarizes the general consensus by asserting that it could be well observed that no researcher to date has successfully characterized the higher education production function. This is because the technologies of instruction, research and community service are poorly understood and the tool for estimating the requisite functional form and coefficient are inadequate to task. In specific terms, in addition to the lack of appropriate measure of quality in the sector, the very nature of the interaction between functions such as teaching and research is difficult to express in mathematical terms. In fact, Gilmore and To (1992) enunciated that existing conceptualization of academic discussion do not offer any empirical evaluation. More pragmatically, they argued that the single output framework commonly utilized often failed to take into account the need to allocate inputs that are used to produce several outputs.

By estimating accurate coefficients, educational production function can show how the demographic variables of teachers such as educational qualification, sex, age, etc. can influence students' academic performance. This set of empirical studies conducted by educational economists examines the relationship between schooling resources and students' outcomes. Students' outcomes have usually been measured by standardized test scores which are regressed on a host of factors such as individual and family background characteristics and measure of school inputs such as class size, teacher experience and education, and expenditure per pupil. In the production function, an efficient school will use a small amount of input to produce a maximum output.

School efficiency can be viewed as a production function, describing educational output as function of inputs. In the educational sector, all inputs cannot be quantified as in a factory. However, educational policy makers can get measures of some inputs such as teacher quality, non-teacher quality, peer group characteristics, school inputs, etc. the research for the educational process has

developed to estimate coefficient of various inputs. As expressed Imazeki (2002), education production function can be viewed as an equation thus:

$$S_{it} = g\ (X_{it}, Z_{it}, F_{it})$$

Where S_{it} = an index of school output

X_{it} = a vector of direct school input

Z_{it} = a vector of students' characteristics

F_{it} = a vector of family and neighborhood characteristics

Cost Function

With a view to improve the quality of public education across the world, researchers have been investigating two fundamental aspects of education system as impact of class size on students' learning and factors directly and indirectly influencing students' performance. The first set of study mainly investigated the relationship between class size and expenditure per student and students' academic performance. The second set of studies investigated how effective are teachers and schools achievement scores. There are mixed responses by researches for example, Hanushek (1986), Riew and Walberg and Fowler found no consistent relationship either between school inputs and students' performance or class size and students' performance.

The issue of economies of scale and efficiency in public education is an issue of ongoing research which plays vital roles in the formulation of a sound policy. Consolidation or merger of low performing and high cost school has been recommended for economies of scale but often one vital question which remains unanswered is "will reduction in cost improve the performance level of the students?" In an attempt to find a school optimal size, past studies have estimated and average cost function for education. However, recent studies have found that in reality there is no optimum size that can deliver a required performance standard with minimum cost in education. An education cost function expresses the relationship between education spending and various characteristics of students' variables, schools and communities that have an impact on the amount schools must spend to achieve some given level of educational outcomes. Thus, an educational cost function is an advanced statistical approach that uses data on school expenditure and outcome to estimate the costs of achieving a desired set of result taking account of uncontrollable cost of variations due to the variables of communities, school and students. This type of analysis can be used predict the average cost of achieving certain performance level in a school. It can also be used to estimate the degree to which the cost of providing public education varies according to differences in school size and student needs. The economic concept of cost function assumes that schools seek to minimize their cost of production for a given output level. It therefore traces out what is called expansion path of costs minimization for a school in terms of output level and the input prices

(Salerno, 2001). In the cost function analysis, an efficient school will use minimum cost in the production of outputs across schools. A "poor" school generally needs a higher level of unit cost to achieve a performance standard equal to that of a "good" school. In this context, a school is said to efficient if it achieves the standard level of performance, while utilizing the minimum resources when compared to its peer. The unit cost of a school depends on the output level it chooses and on the price of inputs. Because of the uniqueness of the output of educational production process, where output is amount of learning rather than amount of instruction, environment is a vital input in achieving a standard performance for any school (Hanushek, 1986). Therefore in education process, a cost function can be expressed as:

$C = \alpha + \beta 1X + \beta 2P + \beta 3N + \beta 4F + \beta 5D + \mathcal{E}$

Where C is the unit cost

X is various measures of students' performance

P is the price of various inputs the school pays such as teacher salary

N is the school size

F is the students' socio-economic status

D is the other students' characteristics

Ɛ is the unobserved school characteristics

One of the crucial unobserved factors in the above equation is the school efficiency. Holding other things constant, a more efficient school most likely would spend less per student to achieve the same standard.

As a method of estimating efficiency, cost function has a number of advantages and disadvantages as highlighted by Gronberg, Janse, Taylor, and Booker, (2004).

A Advantages of cost function as a method of estimating efficiency

- It offers a sound statistical approach to estimation the variation or required spending across schools.
- It assesses the efficiency of a school with respect to multiple outcomes.
- It encourages or forces researcher and policy analysts to be explicit about what outcome are being studied and what input are being considered, as well as what assumptions are being made regarding the behavior of policymakers at the school under analysis.

B Disadvantages of cost function as a method of estimating efficiency

- If the estimation model is poorly specified then the statistical result may even with best data provide a distorted picture of cost-relationship.
- Its theoretical foundation, the cost function presumes that schools are

attempting to provide a designated outcome at minimum cost.

- If the schools are not trying to minimize costs then the cost function is misleading.

- The approach has been criticized because the technical complexity makes it difficult to communicate to the policy-making community.

Data Envelopment Analysis (DEA)

Data Envelopment analysis (DEA) is a technique that allows for measurement of relative efficiency of organizational unit. Its main strength lies in its ability to capture the interplay between multiple inputs and outputs of a process that cannot satisfactorily be probed through traditional ratio analysis (Avkiran, 2007). Suppose that there are producers P1 and P2 who produce the same level of output and producer P1 can make it with less level of input of producer P2 does, then producer P1 is more efficient than producer P2. This illustration is the starting point in DEA methodology. DEA identifies "peer" schools for an individual school and then estimates the efficiency of school by comparing its performance with that of the best practice school chosen from its peers. The idea of best practice is not theoretical and possibly an unattainable concept but schools performing best among their peers which is assigned an efficiency score of 1 or 100%. DEA involves solving a linear programming problem for each school.

Before finding the efficiency value of each school, DEA constructs a best practice frontier (production possibility set) from all individual data in the sample with linear programming technique. Data lie inside the frontier are inefficient and the inefficiency is measured as the distance between the frontier and each decision making unit (DMU).

DEA has two major advantages as a measure of school efficiency that cannot be estimated by units commonly used in economics like profit and price. Firstly, based on linear programming, DEA converts multiple input and output measures into a single, comprehensive measure of efficiency without requiring the relative weights of the analyzed production technology. It does not require any assumption of optimization. It is very appealing to efficiency analysis because schools are actually neither cost-minimizers nor profit-maximizers (Jerry and Thrusby, 2004).

Alexander and Jaforullah (2004) noted the DEA involves solving a linear programming (LP) problem for each school. The solution to the linear programming consists of information about the peers of the schools and the efficiency of the school relative to its peer group. In order to formulate the LP for the school, suppose that there are n schools each producing m outputs by using p inputs and the objective of a school is to minimize inputs given an output level.

The input-oriented LP problem of the nth school is to
Min *Øi*
Øi, Z
s.t. – y + Yz≥
ØiXi - XZ≥
Z ≥O
Where y is an mxm matrix of outputs with element yij representing the quality of the ith output of the jth school, X is a psm matrix or inputs with element xkj representing the quantity of the kth input of the jth school, yi is the mxl vector of the ith school's outputs, xi is a pxl vector of the ith school's inputs, z is an nxl vector of weights and Øi is a scalar that indicates the efficiency of the school. The value Øi varies between zero and one. A value of one implies that the school is 100% and a value less than one implies the school is (100) Øi percent efficient relative to the "best practice" school.

Quality indicator

The discussion of the input and output as it affects efficiency is incomplete without referring to quality problem associated with different inputs and output indicators. Quality is a multi-dimensional phenomenon that is associated with a product or service produced by a school. An important indicator of quality as it relates to school inputs and outputs is the technical quality of the product. Measuring quality of inputs and outputs of educational institutions is therefore a complex problem and this central in the discussion of school efficiency.

Once there is recognition that considerable variation exists in the quality of the output produced by schools, the question is how can we account for quality differences in efficiency studies? The first option as highlighted by Coelli et al. (2005) is to incorporate the quality differences into the outputs measures, that is, one could attempt to derive quality-augmented output model. Secondly, it may be possible to accord some numerical weights to output of different quality. But one should use an objective approach to identify weights. The third option is to apply a two stage approach to account for differences in quality of output. In the first stage, unadjusted output measures are used for the purposes efficiency analysis and the second stage is to indicate quality characteristics directly in the method that is used for estimating technical efficiency.

Finally, the quality variation in output is an important issue that deserves careful consideration in analyzing school efficiency. It is important that an attempt is made to account for variation in the quality of output of educational process.

Conclusion

The cost of producing education outcome depends to a greater extent on the size of the school, the cost of input (such as teacher salaries) and on the

environment in which the education outcomes are being produced. More difficult environment leads to a higher cost of achieving any given level of student performance. The cost at which a school can achieve a specified level of student performance thus depends on the performance level itself, on the salary and allowances teachers and other personnel, the characteristics of students and their parents, the size of the community and the location of the school. Many of these factors are largely beyond the control of the school and this to a greater extent influences the efficiency of a school. This is because efficiency is a function of many variables depending in the interests of the researcher and abilities of the practitioners.

Educational administrators and policy-makers must be aware of these variables in order to manage them in such a way that will assist the school and the education sector in achieving its objective. Moreover, based on the models presented in this paper, educational administrators must keep adequate records of these required variables so as to be able to use them for research purpose.

Researchers attempting to estimate efficiency of schools must be aware of the fact that they have great tasks ahead. This is because choosing inputs and outputs of educational process is a great task on one hand and the estimating technique to be used on the other hand. Researchers should as a matter of necessity acquaint themselves with all the approaches for measuring efficiency. They should clearly define their objectives, because this will guide them on which of the models to be adopted in estimating efficiency.

Recommendations

Based on the technicalities involved in the application of the models identified above in assessing efficiency, it is recommended that:

1. Resource allocation to schools should be based on the needs of individual schools and not on the political consideration of the government. This will minimize wastes in schools.
2. Professional organizations such as the Nigerian Association of Educational Administration and Planning (NAEAP) should organize conferences and workshops to introduce various approaches to measuring efficiency to researchers and practitioners.
3. Educational administrators should identify school-based variables that are germane to estimating efficiency and take proper care of them for administrative decision-making and research purposes.
4. Parametric and non-parametric approaches to measuring efficiency should be incorporated into the educational administrators training programmes.

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