Exploring the Innovative Methods for Evaluating Educational Efficiency

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Abstract*— The aim of this study is to provide information about educational efficiency by synthesizing existing literature, with an emphasis on techniques used to assess educational efficiency for the Decision-Making Unit (DMU). A thorough search of the existing literature was done using the terms 'Education Efficiency,' 'School Performance,' and 'Efficiency Measurements' in the related systematic databases of 'Web of Science' 'Scopus,' and 'Google Scholar'. The search yielded 1500 articles published between the years 2010 and 2021. The results indicate that nonparametric approaches Data Envelopment Analysis (DEA) and parametric approaches Stochastic Frontier Analysis (SFA) are the primary methodologies utilized in the literature to drive the most significant metrics of education efficiency, based on pre-determined inclusion measures and a theme evaluation. The results of this study are expected to provide important insights and advantages to education's key stakeholders. Aside from adding to the existing literature on educational efficiency, this study has the potential to inform ongoing educational changes taking place significantly and promptly throughout the world.

Keywords—Education Efficiency, School Measurement, DEA, SFA, Systematic Review.

I. INTRODUCTION

Education is essential to the transmission of a society's ideals and acquired knowledge [1]. The field of school efficiency has emerged as one that has been widely acclaimed, investigated, and quantified by academics from across the globe, using techniques like Data Envelopment Analysis (DEA) which is a parametric method, and Stochastic Frontier Analysis (SFA) as parametric method [2]. To maximize educational efficiency, researchers recommend that educational systems provide an adequate, long-term, and high-quality education while keeping costs as low as possible [3, 4].

As stated by research, there is a lack of consistency in the quality of education [5]. In the absence of comprehensive data, evaluating the effectiveness and efficiency of educational institutions can be difficult. According to [6] noted that most school-related research has concentrated on how spending influences students' performance, but almost never considers how effective expenditure occurs. In addition, determining school efficiency is difficult because of the vast number of inputs and outputs involved [2]. Knowing how to enhance school efficiency is a significant challenge for governments and policy makers in any nation as the primary operators and financiers of education institutions, as well as other stakeholders [7]. Furthermore, closing the achievement gap amongst public school pupils is one of the existing difficulties [8]. Given the foregoing, the study aims to sift through the pertinent literature in order to shed light on the techniques employed, as well as the methods of DEA and SFA for evaluating schools' efficiencies in their duty of delivering quality and long-term education.

II. REVIEW OF THE LITERATURE

A. Efficiency on Education

Education is the process of obtaining skills and knowledge as well as values, attitudes, and habits, in order to enable people to grow to be productive members of culture. Study [9] stresses the importance of education is comprised of experiences that make individuals grow with a healthy personality, enabling them to positively impact society and themselves. Emrouznejad and Cabanda, on the contrary, defined efficiency as the capability to attain a product with the fewest resources [10].

Efficiency is the ability to accomplish a task efficiently and with the fewest resources possible [11]. A firm consider fully efficient, if it is able to sustain its productivity while utilizing little input, where inputs refer to materials and resources necessary to perform the task. In educational contexts, the proportion of total weighted output to total weighted input is described on a study done by [12]. Using sources efficiently indicates that the observable output from education firm will result from using the least number of resources, but resource effectiveness indicates that society will get what it wishes to see from the use of resources in education.

Education efficiency is described in the literature as the total weighted output and input ratio [3], illustrated in the equation below:

$$\text{Efficiency} = \frac{\text{Total Weighted Output}}{\text{Total Weighted Input}}$$

B. Measuring School Efficiency

Education is an extremely complicated process, and we can only provide a partial summary in the form of a production function. Various approaches have been used to measure efficiency, but the majority of studies using frontier methods in education have been non-parametric (DEA, Free Disposal Hull (FDH), order meta frontiers) or parametric (SFA). In education, nonparametric methods such as DEA (in its various variants) has been utilized extensively in the field of education, and it is among the top five applications of this methodological approach, however, to the method of SFA has been applied rarely to education sector [13].

In DEA the optimal frontier is determined by mathematical programming; functional forms are not imposed [14]. The DEA is derived from the outputs and inputs of entities called Decision Making Units (DMUs). In this case, all of the schools (DMUs) are compared with the best schools [15]. DEA major advantage on measuring efficiency is that no assumptions can be made about the analytical form of a production function a priori. DEA uses data reduction techniques to identify the production function. Regression analysis relies on average observations, but DEA relies on extreme observations, which results in DEA's foremost disadvantage: the frontier is sensitive to extremes. DEA also assumes that no random errors occur along with any deviation from the frontier reflects inefficiency within the DMU [15].

Alternatively, the method SFA refers to the parametric frontier model with a two-component error term. Studies by [16, 17] developed this approach concurrently. They began by modelling stochastic production frontiers, or efficient frontiers in which a producer's output is impacted by both specific inefficiency and external shocks. When using SFA is necessary to perform a system of factors analysis on a priori basis as well as under some assumptions, whose strength may vary according to each model, in order to determine the relationship between input components and output [18]. Also, SFA utilizes data to estimate its parameters econometrically rather than hypothesizing a functional form. Aside from technological inefficiency, measurement errors, statistical noise, or other non-systematic factors may also affect units deviating from the production frontier using SFA. Moreover, both statistical random error time series and inefficiencies that are not negative time series require strict distribution assumptions [19].

C. Methodological approaches used on Previous studies

Efficiency can be determined empirically in several ways [20], the most popular method in the field is the application of DEA (in its many variations), education has also been a significant area of application [21]. SFA, presented by [16, 22, and 17] are examples of parametric techniques.

The previous studies related to assessing the efficiency of education dealt with the measurement either at the level of universities, schools, and assessment for students themselves. It is noteworthy that by looking at most of the previous studies, two popular measurements were used, DEA and SFA methods, however, DEA method has the largest and preferred share for measuring the efficiency of the education sector, so that we note that SFA method is used more in other fields such as the economic and financial sector, such as measuring the efficiency of banks.

This study offers an overview of the studies conducted by the both DEA and SFA to assess the education efficiency. The purpose of this review is to provide a comprehensive overview of how both methods are used to the evaluation of school efficiency in this research. For starters, there are several research that have used DEA to assess school performance such as [4, 7, and 23]. they used the DEA technique to assess high school efficiency. The study discovered that the scientific facility at the school had an impact on enhancing school efficiency. Study by [4] (2019) used a two steps DEA technique to investigate the Greece efficiencies schools.

To estimate efficiency school, as stated by [7] which they used a two-stage DEA method. The school efficiency was measured in the first stage, as part of the second stage, variables related to community were examined, such as class size, high-qualified instructors, and school costs, on school efficiency. In addition, [24] used the 2011 TIMSS information to predict the effectiveness of elementary schools in Morocco. Primary schools were also assessed using the DEA. To assess the efficiency score, [25] used DEA in Australian government schools. The cost efficiency levels of the study were assessed using two stages. Their findings revealed that schools in Australia are diverse. The Mastercard Foundation utilized DEA as the major approach in a study report on the efficiency of secondary education in the EESSA initiative in Sub-Saharan Africa [26].

In a study report on secondary education efficiency published by [26], inputs included school performance characteristics, headteacher performance and quality, teachers' qualifications, students-to-teacher and student-to-computer ratio, employment and allocation of teachers, and costs. [2] looked at primary school efficiency as a predictor of student achievement. In the first stage of the analysis, the efficiency of the school was calculated, followed by a regression analysis of its efficiency using its characteristics and the surrounding environment in the second stage. [24] performed research on primary school efficiency to offer a measurement of primary school efficiency. The study found that a student's socioeconomic surroundings has a substantial influence on the school's efficiency.

Additionally, [27, 28] provided a comprehensive review of the research on educational effectiveness through describing the techniques used as well as the usage of data sources in prior research. Numerous researches using DEA and SFA methods were discovered in their systematic review such as [29, 30, 31, 32, 33, 34, 35, 36, 37 and 38]. In contrast, past researchers used SFA to assess school efficiency, including [36, 39, 40, 41, 42, 43, 44 and 45].

D. Inputs and Outputs Variables on Educational Efficiency Measurement Studies

There are a variety of educational inputs into schools that might be examined when attempting to explain and quantify efficiency. In general, inputs can be divided into two categories: endogenous inputs, also known as discretionary variables, schools can manipulate discretionary variables, as well as non-discretionary variables, which are outside of their control. The most important endogenous inputs are human and educational resources. This comprises running teaching and expenses personnel [46], a school administration that emphasizes strong leadership, staff involvement, and appropriate rewards will have effective management [46].

In addition to such inputs, schools should have effective monitoring, like regular evaluations of instructors' performance, student evaluations, and evaluations of general school effectiveness. Other inputs include effective monitoring. In addition to efficient topics, clear objectives, clear content, and well-organized lessons are other types of input that contribute to good classroom management. Pedagogic features, for example, students should actively participate, and instruction should be effective and getting maximum usage of available studying schedule, among additional things. The social background of the students as well as their previous educational attainment as well as gender, ethnicity and eligibility for free school meals can all influence their academic performance [47]. Table 1 presents a varieties of inputs variables in education efficiency measurements studies.

For the output variables, academic performance is an important output in the evaluation of efficiency evaluation [28]. Academic performance refers to the percentage of students passing a test as well as the grades they achieve in a particular subject are the most supported variable in the literature for quality. Additionally, there are other outputs used in the school efficiency measurement such as enrolment rate, dropout rate, and rate of attendance [28].

Table 1: Inputs Variables in School Efficiency Measurement Studies

Categories/ Variables	Factors
Variables Relating To Students	
Psychological and behavior	Motivational/inspirations
	Peer group
	Predicted attainment
	Previous academic achievement
Demographic	Disabilities (extra educational requirement)
	Free lunch/pay full lunch
	Grants
	Gender/Age/Marital status
	Background of language (level of English proficiency)
	Race/ethnic/nationality
	Lifestyle
Variables Related To Family	
	Parental education
	Economic needs
	Family structure
	Availability of resources at home
	Socio economic (employment, family income)
Variables related to education institutions	
	Tuition fees/Research income/outside funding
	Size (students' population, students per class, gender
	Student to teacher ratio
	Gender-age-race teacher
	Education/experience teacher
	Salary for teacher

Source: [28]

III. METHODS OF THE STUDY

Based on the current research, this study examines the use of the major widely used methods of data envelopment analysis (DEA) and stochastic frontier analysis (SFA) in order to assess schools efficiency. The systematic review technique was employed in this work, with the research goal of identifying, evaluating, and debating the drivers and implications of methodologies for measuring school education efficiency. As a result, the identified key phrases 'School Performance,' 'Education Efficiency,' and 'Efficiency Measurements' were utilized to do a literature search using the databases 'Scopus,' 'Google Scholar,' and 'Web of Science'.

IV. RESULTS AND DISCUSSION

Based on the findings, frontier techniques have been extensively utilized in the literature on efficiency in education in two forms, non-parametric DEA and parametric SFA. The results show that most education research on school efficiency employ the DEA technique more than the SFA method. Researchers have shown a strong interest in frontier models. The rationale for this is that the frontier idea properly displays the key qualities of evaluating efficiency by attempting to measure how efficiently an organization achieves maximum output with minimal input consumption.

Even though both approaches are extensively utilized, each has advantages and downsides. For starters, non-parametric techniques can easily accommodate many inputs and outputs, whereas most stochastic approaches necessitate the selection of an individual variable. Second, DEAs do not require any assumptions about the functional form of the error term definition, whereas SFAs do. Furthermore, non-parametric methods are assumed to produce all deviations from the frontier due to inefficiency.. This means that estimate boundaries are difficult to calculate, and standard models do not provide statistical significance.

V. CONCLUSION

This study significantly contributed to the current literature on educational efficiency This will allow a deeper understanding, which will enable a more nuanced understanding of the issue. The study's findings are anticipated to give important stakeholders in public education, such as management of schools and stakeholders at the grassroots level, with insights and benefits in mobilizing appropriate resources to improve student performance. The data might also help curriculum authors and the Ministry of Education discover efficiency measurement approaches that are crucial for getting the greatest results.

According to the findings, the efficiency in education literature has mostly utilized frontier techniques in two forms: non-parametric (DEA) and parametric (SFA). Frontier models have piqued the interest of many scholars. The reason for this is that the frontier idea properly depicts the key aspects of evaluating efficiency by attempting to measure how efficiently an organization achieves maximum output with minimal input consumption. Despite their popularity, each technique has pros and downsides. Unlike stochastic methods, non-parametric procedures are more likely to accept multiple inputs and outputs, but they need a single explicative variable. Non-parametric processes do not require assumptions about the representation of the error term or its functional shape, as stochastic methods do. All deviations from the frontier are thought to be the result of inefficiency by non-parametric

analysis as well. Therefore, most models are incapable of determining estimate limits, and statistical significance is not available.

Most previous research' techniques were based on DEA approaches, while other studies employed SFA [12]. Future research should analyze the effectiveness of homogeneous units that employ numerous inputs to create several outputs using DEA along with SFA, depend on the restrictions. Because it has been applied in several previous research studies to examine the efficiency of the educational industry, this approach may be beneficial for future empirical investigations.

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