COMPARING THE TECHNICAL EFFICIENCY OF INDIAN STATES – DEA APPLICATION

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ABSTRACT:
Skilled resources are of utmost importance in the advancement of an economy. The establishment of a strong foundation of knowledge through higher education is a critical component in India's progress. India boasts an extensively developed higher education system that offers comprehensive education and training in all areas of human innovation and intellectual pursuits. The implementation of national policies necessitates substantial resources over an extended period and often generates significant amounts of data, which is essential for evaluating their efficacy. This research paper focuses on assessing the efficiency of higher education in Indian states during the years 2011 and 2020. Employing Data Envelopment Analysis, we qualitatively investigate the efficiency of higher education using models that incorporate two inputs and two outputs. In consideration of data availability, we have selected the total enrolment and the number of graduates as outputs, as the number of individuals completing their degrees pertains to the success of teaching endeavours. Additionally, we have included the number of students per teacher as an input factor, as it serves as a qualitative indicator. The calculated DEA scores are based on input-oriented constant returns. In this model, we treat one state/UT as the Decision-Making Unit (DMU). The results reveal the performance of the 33 states identified as DMUs for the years 2011 and 2020. Consequently, these findings facilitate the assessment of the progress or decline in the performance of specific states or UTs through comparative analysis. In 2011, there were 33 DMUs, of which 6 were classified as efficient. In 2020, there were 34 DMUs, with 3 of them achieving efficiency scores of 1. It is noteworthy that Bihar, New Delhi, and Tamil Nadu maintained their positions as having highly efficient higher education systems, as evidenced by their score of 1. Furthermore, this paper aids in identifying the most efficient DMU when considering academic efficiency among the compared entities.

Keywords: *Economics, Higher Education, Economics of Education, Human Resource, DEA*

Introduction

India holds the top position globally when it comes to population, with a median age of 28 years (Worldometer.info). The escalating population and the burgeoning demands of the job market have propelled the significance of higher education to unprecedented heights. Consequently, India's higher education system has undergone substantial transformations over the years due to the dynamically evolving circumstances. The surge in demand for higher education enrolment has outpaced the demand for graduates in the job market, necessitating a comprehensive examination of the efficiency of the higher education system, particularly in the context of India. This need arises primarily because over 40% of the Indian population comprises individuals under the age of 25 (PEW Research Centre, 2023). Additionally, as India strives to cement its status as a burgeoning economy, there is an increasing requirement for a larger pool of skilled graduates. Policymakers attach great importance to ensuring that the younger generation pursues college degrees and that graduates possess the necessary competencies to secure gainful employment in the job market. Recognizing this imperative, the University Grants Commission (UGC) has been incessantly working towards augmenting higher education in terms of faculty, infrastructure, teaching methodologies, and research endeavours. Terms such as accountability, efficiency, and effectiveness have become the focal point of discussions and research in this domain. Against this backdrop, this paper undertakes a comprehensive analysis of the efficiency of higher education systems across the various states and Union Territories (UTs) in India. The fundamental question that looms large is whether we can qualitatively assess the efficiency and identify areas that require improvement. The present investigation constitutes a vital addition to the body of scholarly works that examine the efficiency of higher education in different Indian states. The paper presents an insightful interpretation of the diverse efficiency scores attained by each state. For every state, we possess a wealth of information in the form of variables that contribute to the efficiency scores derived from the Data Envelopment Analysis (DEA) formulations. Specifically, we incorporate two inputs, namely the pupil-teacher ratio and the total number of colleges in each state, along with two outputs, which encompass the total enrolment and the number of graduates across undergraduate, postgraduate, and PhD levels. Notably, enrolment can function both as an input and an output depending on the context of educa tional institutions. This paper is divided into four sections, Section II deals with Literature Review, Section III deals with methodology which includes data and results and Section IV concludes with the discussion.

Literature Review:

Economics of Education is relatively a fresher field of research where education, its demand, its finance, policies, and comparative analysis are done to ensure the best output can be extracted from the available resources. Economics of Education becomes even more important in developing countries with the rising population, as governments there have to make policies to increase the efficiency of education and learning systems to produce a trained and coherent human resource. Adam Smith, the Father of Economics, mentioned the relationship between economics and education (Smith A. , 1776). Economists like J. S. Mill, A. Marshall, and Karl Marx have also recognized the importance of education in the process of economic growth and development. The term "Economics of Education" was coined by Schultz at the American Economic Association the 1960 (Schultz, 1960). Koopman was the first one to define technical efficiency in the year 1951 (Koopman, 1951). Then, Nobel Laureate Gérard Debreu defined the coefficient of resource utilization with technical efficiency in the same year 1951 (Debreu, 1951).Even, American economist Michael James Farrell attempted in the year 1957 to provide a measure of productive efficiency using all inputs (Farrell, 1957). Another American mathematician Abraham Charnes also proposed the use of a non-parametric approach for measuring the efficiency of decision-making units (DMUs) using the Charnes Efficiency score from 0 to 1 (Charnes, Cooper, & Rhodes, Measuring the efficiency of decision making units, 1978). In this method, no DMU can be considered efficient unless all slack variables are zero. This shows, Economics of education has seen quite lengthy research by established personalities and institutions world-wide. The method to calculate the efficiency of not-for-profit organizations was proposed by Abraham Charnes and William Wager Cooper 1980 (Charnes & Cooper, 1980) and illustrated by the Program – Follow – Through in the US. public schools. Through this paper, it was shown that in order to assess the amount of improvement in the DMU, first it is brought under the envelope and then the further gain is adjusted by moving the observations & till further gain of efficiencies is studied. Charnes explained how to use Data Development Analysis for finding the relative efficiency and relief of DMUs. This study was improved by British Scholars A M Bessant & E W Bessant in their paper (Bessent & Bessent, 1980) where 55 linear programming models were solved each for a school using 12 inputs and 2 outputs. Slack values and the opportunity cost of each DMU were found. They demonstrated how inefficient DMUs deviate from efficient DMU. Bi-internal principles provided for the determination of multi-dimensional extreme frontiers. Charnes, Cooper, & Rhodes (1980) used Farrell's technical efficiency to test the efficiency of program follow-through (PFT) relative to the non-follow-through (NFT) in the US (Charnes, Cooper, & Rhodes, 1981`). This study differentiated program efficiency from managerial efficiency. DEA help us to distinguish good programs that might be managed badly from a worse program that appear to be better because of management than program capability. A similar study was applied to 167 elementary schools out of which 78 were found to be inefficient (Bessant et al, 1982) Abraham Charnes, in 1982 introduced the multiplicative model for DEA which uses constant returns to scale by employing virtual inputs and virtual outputs. Frontier is piecewise log-linear than piecewise linear form. This method was improved by adding virtual input multiplier and virtual output multiplier by Charnes et al. (Charnes, Cooper, Seiford, & Stutz, 1982). Till now CCR model of DEA was being used by most researchers, until Charnes, Cooper, Golani, Seaford and Stutz, 1985, inked the limitations of the CCR model. Michael James Farrell's paper as earlier confined to a single output situation, which is unlike the real-world situation where there are multiple outputs. On the other side, Charnes et al (1985) had improved the single input, single output to multi-input, multi-output through virtual single input and virtual single output

(Charnes, Cooper, Golany, Seiford, & Stutz, 1985) and further in 1986 the non-Archimedean elements instead of points at infinity was introduced. (Charnes & Cooper, 1982) Till now DEA was being explored by various economists, but Sexton et al (1986) noted the limitations of DEA (Sexton, Silkman, & Hogan, 1986). For example, for DEA can be used for technical efficiency and not price efficiency. Moreover, it's module cannot tell if a DMU is producing highly valued output mix or not using the available input set. Sexton, Silkman and Hogan suggested ways to eliminate the limitations of DEA through the use of goal programming to develop cross-efficiency, cluster analysis, analysis of variance and pooled cross-section time-series analysis. A lot of development took place in the application of DEA for the analysis of efficiency in the profit as well as not-for-profit industries. Even Indian Economist J K Sengupta in his research along (Smith & Mayston, 1987) and (Jesson, Mayston, & Smith, 1987) compared Education sector with industries like cement, steel and used DEA method to compare stochastic variations of the input and output data. The benchmarking and constraint facet were employed for calculating the efficiency frontier of a production process (Ahn, Charnes, & Cooper, 1988) and (Bessent A. , Bessent, Elam, & Clark, 1988). The authors developed a mathematical approach based on the concept of a constraint facet, which is a subset of the feasible production space that is defined by a set of constraints J K Sengupta (1989) used stochastic input-output data to develop a methodology for estimating the efficiency of a production process by comparing its input. Output coefficients to the coefficient of benchmarking system (Sengupta, 1989). These methods were then applied for the calculation of efficiency for DEEP programs (Diamond & Medewitz, 1990), efficiency of university departments (Beasley J. , 1990) and Academic Department, Efficiency via DEA (Sinuary-Stern, Mehrez, & Barboy, 1994). In continuity with this, a complete system for evaluating the efficiency of various processes, including the use of inputs and output to measure productivity was given (Charnes, Cooper, & Thrall, 1991). The authors provided details for the factors that influence efficiency like resources, technology, management, etc. A positive correlation was found between teaching and research productivity. among university faculty members. Faculty members who taught more courses tended to publish more, articles and research (Beasley J. E., 1995). Prices of inputs play an important role in determining the efficiencies of the DMUs. The mathematical approach to jointly estimate input prices and efficiencies for public service was widely accepted in subsequent DEA research. Sensitivity and stability of efficiency classification were important for efficiency changer when making decisions about DMU restructuring (Charnes, Rousseau, & Semple, 1996). Increasing demand for enrolment in higher education made it mandatory to evaluate the efficiencies of universities and their academic programs to access factors like size and research orientation (Athanassopoulos & Shale, 1997). DEA method would only mark the DMUs into efficient or inefficient units. Canonical- Correlation Analysis provided full rank scaling for all units rather than a categorical classification of efficient or inefficient units (Friedman & Sinuary-Stern, 1997). DEA has also been compared with regression analysis. Regression uses OLS algorithm while DEA uses LP to fit a convex wall. Regression is more flexible but DEA is better suited for identifying the most efficient units in a data set providing valuable insights (Cubbin & Tzanidakis, 1998). These methods were used to assess the cost efficiency of 520 school districts in New York where the mean inefficiency came out to be 14% (Ruggiero & Vitaliano, 1999) and in the case of Mexican state-level education expenditure an efficiency -equity trade-off was conducted to assess changes in the allocation patterns by comparing 1980 & 1990 cross-sections (Gershberg & Schuermann, 2001). Stochastic frontier analysis and DEA was used for a sample of 2000 schools in Chile. The schools displayed an average technical efficiency of 0.93 as measured by the stochastic frontier method ranging from 0.73 to 0.98 (Mizala, Romaguera, & Farren, 2002). 1256 Florida elementary schools showed an inefficiency of 4.1-5.1% range (Conroy & Arguea, 2008). While the technical efficiency of public elementary schools in Kuwait examined between 1999-2000 and 2004-05 using DEA was found to be carried between 0.695 and 0.858 (Burney, Johnes, Al-Enezi, & Al-Musallam, 2013). DEA in combination or comparison with regression has been used extensively for higher education actors around the globe. McMillan & Datta (1999) used regression to find the efficiency of 45 Canadian universities (McMillan & Datta, 1998). Similar studies and methodology were applied to public education in Utah (Chakraborty, Biswas,

& Lewis, 2001), 2547 economics graduates from UK universities in 1993 (Johnes, Measuring teaching efficiency in higher education: An application of data envelopment analysis to economics graduates from UK Universities 1993, 2006), for investigating the efficiency of Australian universities using non-parametric frontier techniques over the period 1998-2003 (Worthington & Lee, 2008) and for the efficiency of research 109 Chinese regular universities in 2003 & 2004 (Johnes & YU, 2008). A cost efficiency analysis was conducted in 42 departments in the UAB, Barcelona, in 1996-98 and found that departmental costs could be reduced by an average of 46% in the long term (Gimenez & Martínez, 2006). The technical and scale efficiencies of 100 HEIs in the UK for the year 2000-01 were found higher than average (Johnes, 2006). DEA has also been applied to assess the efficiency of 944 HEIs in 17 European countries. The study found that the most efficient were Sisak Republic, Belgium & Latvia whereas Denmark and Norway showed the lowest efficiency (Veiderpass & McKelvey, 2016). A similar study was carried out in India on 4 technical higher education institutes over 5 years (Sahney & Thakkar, 2016). Barra & Lotti (2016) conducted efficiency on two large groups of science and technology (ST) and Humanities and Social Sciences (HSS) based on the data from 2005 to 2009 and found that ST is more efficient than HSS in terms of research activities while HSS achieves higher efficiency in teaching activities (Barra & Zotti, 2016). External factors like size and department composition, locations, and funding structure play an important role in determining the efficiency of the Higher Education Index (Wolszczak-Derlacz, 2017). Universities receiving large financing play a pivotal role in the development of a region and regional economy (Firsova & Chernyshova, 2019) and (Salas-Velasco, 2020). Analysing the efficiency of higher education institutions is a complex task as there are several complex variables to be involved and evaluating the output is also difficult. In 2000, Fare & Grosskopf proposed Network DEA which was used by for multistage evaluation. of higher education institutions in Brazil's (Tavares, Angulo-Meza, & Sant'Anna, 2021) Absence of a market mechanism also affects the efficiency of public higher education institutions. HEIs having international programs have higher efficiency scores than those w/o international programs (Tran, Pham, Nguyen, Do, & Pham, 2023). Higher education in institutions is expected to deliver beyond the graduate numbers and research. The increasing demand for enrolment in undergraduate courses, the dearth of eligible graduate incorporates and the increasing unemployment & of educated youngsters make it even more important to analyse the efficiency of educational systems in the Indian context (Loganathan & Subrahmanya, 2023).

Research Methodology

Data was obtained from All India Survey of Higher Education which provided state wise data. The data set includes information about central universities, state public universities, and all other universities that cover the higher education system in various states. AISHE aimed to build a comprehensive database and provide an accurate picture of higher education in India by collecting data directly from institutions online. The survey covers all higher education institutions in the country and categorizes them into three broad categories: universities, colleges, and stand-alone institutions. The data collected includes information on teachers, student enrolment, programs, examination results, education finance, infrastructure, and other parameters. The survey also calculates various indicators of educational development, such as Institution Density, Gross Enrolment Ratio, Pupil Teacher Ratio, and Gender Parity Index, based on the data collected. Together these account for a compounded annual growth rate of around 3.5% over 5 years from 2016 to 2020. In the year 2020, Bihar had the highest average enrolment per college. The study uses 2 inputs and 2 outputs model. Three degrees have been included in the study – undergraduate, postgraduate and PhDs to cover a major part of higher education. Enrolment and out pass numbers have been kept as outputs whereas total no. of college per state and pupil-teacher ratio has been considered as qualitative inputs. Variables such as pupil-teacher ratio can be described as efficiency-related. To make the efficiency judgment more comprehensive, the DEA approach has been used. The assessment of efficiency in the context of Higher Education has been a long-standing application of DEA. Those interested in exploring early examples of this can refer to the work of Diamond and Medewitz, for instance (Diamond & Medewitz, 1990). When it comes to specifying a DEA model, one must make a decision on which inputs and outputs to include. This decision has been a topic of concern for quite some time, as the inclusion or exclusion of an input or an output can have an impact on DEA scores. Scholars such as Parkin and Hollingsworth (Hollingsworth & Parkin, 2003), as well as Jenkins and Anderson, have delved into this matter. Striking a balance between parsimony and information redundancy is the usual aim when dealing with DEA. On one hand, we strive for simple models that encompass all the relevant information within the system under investigation. However, we also worry about the exclusion of pertinent variables. On the other hand, we endeavour not to incorporate irrelevant variables into the model to avoid the problem of over-fitting. The dilemma of including or excluding variables was initially addressed by Norman and Stocker (Norman & Stoker, 1991), who proposed estimating efficiencies without certain variables and correlating the efficiency scores with the values of the omitted variable to assess its impact on the results. Expanding on this line of thought, Pastor et al. developed a systematic procedure for specifying a DEA model. They assessed the impact of including or excluding a variable on the efficiency of a particular decision unit and employed statistical analysis to summarize this impact. While these approaches are valuable in the selection of a model specification, they do not elucidate how a particular specification reveals the strengths and weaknesses of a specific unit under assessment. This issue was tackled by Serrano-Cinca and Mar-Molinero, who estimated a range of specifications and analysed the results using multivariate statistical analysis. The concept of estimating multiple models to gain further insights has also been adopted by Liu et al (Liu, Louis, Wen-Min, & Bruce, 2013), who utilized a network-based approach to uncover the characteristics of the results. The choice of variables for the DEA analysis has been based in an attempt to capture the inputs and outputs in qualitative terms irrespective of the size of the state. The literature in this field agrees to consider human and financial resources as inputs, measuring them for instance through the number of academic staff, expenditure per student, and similar. In this sense, universities are considered multiproduct organisations that produce the outputs using the inputs jointly. On the output side, the preference goes to the number of graduates (as for teaching). In this paper, based on data availability we have chosen as inputs the number of total enrolments, and number of pass outs as the number of graduates is related to the success of the teaching activity. Qualitative assessment can be through number of students per teacher, hence it has been included as an input. The DEA scores have been calculated using an input-oriented constant returns to scale (CRS) models

Results

We conducted the tests in two ways for the years under discussion, that is, 2011 & 2020. Firstly, the model was run for 2 inputs and 2 outputs

- O1 - UG + PG+ PhD Enrolment
- O2 - UG + PG+ PhD Out pass
- I1 - Total No. of Colleges per state
- I2 – PTR (all variables to be considered for 2011 and 2020 respectively)

Based on the inputs and outputs, the technical efficiency of higher education for states and UTs is estimated by DEA and an input-based approach and constant returns to scale are adopted. Andhra Pradesh, Bihar, Chandigarh, Delhi, Tamil Nadu, and West Bengal showed 100% efficiency that is their score was 1. These are followed by Maharashtra with a score of 0.9044 at 7th rank, followed by Uttar Pradesh 0.8503 at 8th rank and Karnataka with a score of 0.7766 at 9th rank. Now let us have a look at the input resources of these states. Bihar and Delhi had the maximum pupil teacher ratio of 46 and 48 respectively, meaning a smaller number of resources were catering to maximum number of students acting as outputs of educational institutions. In 2011, even Chandigarh and West Bengal had high pupil-teacher ratio of 25 and 36 respectively. Technical efficiency refers to a firm's capability to maximize output by utilizing a predetermined level of inputs, in light of the current technological advancements. Additionally, it can also signify a scenario wherein, despite the present technical expertise, enhancing output from given inputs or generating a specific output with less than one input without increasing the usage of another input is unattainable (Farrell, 1957). So, in the case of Chandigarh, West Bengal, Bihar and Delhi the efficiency scores are high majorly because these states have been producing more outputs with relatively a smaller number of colleges and a very high pupil teacher ratio than the national average of 24 pan India. In 2011, there was a boom of privately owned engineering colleges in states like Andhra Pradesh had more than 80% private unaided colleges and Tamil Nadu had more than 76.8% private unaided colleges. According to AISHE report, the states bagging the highest scores are the ones having maximum number of colleges (whether government or privately owned) - Uttar Pradesh, Andhra Pradesh, Maharashtra, Karnataka, Rajasthan and Tamil Nadu. Among the states that have 100% efficiency we can see a clear demarcation of two groups of states- one group has a maximum number of colleges per lakh population and another is the one producing maximum output with minimum resources. Andhra Pradesh and Tamil Nadu have more than 25 colleges per lakh population hence having more campuses, Chandigarh has 19 colleges per lakh population, whereas Bihar, West Bengal, and Delhi have 6, 8 and 9 colleges per lakh population. Hence Bihar, West Bengal, and Delhi were achieving maximum output with a limited set of resources like colleges and number of teachers. Andhra Pradesh and Tamil Nadu were seen achieving maximum output by utilising all resources at work. Now let us look at the data of 2020. When we examine the data of 2020, we find that 3 states Bihar, Delhi and Tamil Nadu happen to retain their first position with a 100% efficiency score. Colleges per lakh population in Bihar and Delhi are 8 and 9 respectively with highest pupil teacher ratio. The PTR in both DMUs has been consistently high. For Delhi the high number of enrolments in degree courses can account for the burden on the teaching resources and in case of Bihar, the non-fulfilment of vacancies seems a plausible reason for the number. West Bengal has an efficiency score of 0.9938 with 13 colleges per lakh population and the PTR is 31.

Conclusion and Discussion:

The allocation of substantial funds by the central government towards the provision of education as a public good is an area of focus. Both the central and state governments have prioritized higher education in previous plans. To evaluate national policies, significant volumes of data, in the form of official statistics, are gathered by organizations such as AISHE. It is imperative to analyse this data in a manner that is comprehensible to individuals. This study endeavours to determine whether, based on official statistics, we can ascertain whether the resources provided by the state and central governments are excessive or if there is a deficit. Additionally, it explores whether the resources are being utilized adequately or if the governments are placing strain on teaching and infrastructural resources in order to accommodate the increasing number of enrolments. The model employed in this research aims to elucidate the role of the DMUs (states and UTs) within the efficiency framework. We selected two inputs and two outputs as qualitative variables to compare the scores of 2011 and 2020. For a more comprehensive analysis, we can assess the impact of inputs on the efficiency score of states to gain a deeper understanding of the dynamics at play.

Table 1 · Showing the Standard Deviation, Correlation Coefficient, Score and Ranks for all states for 2011.

Statistics on Input /Output Data	Total No. of College - 2011	PTR – 2011	UG + PG+ PhD Enrolment – 2011	UG + PG+ PhD Out pass – 2011
Max	4828	48	3981819	1089883
Min	6	9	3616	105
Average	1056.12	26.0909	806751	200143
SD	1423.02	9.44317	1003505	258603
Correlation	**Total No. of College - 2011**	**PTR – 2011**	**UG + PG+ PhD Enrolment – 2011**	**UG + PG+ PhD Out pass – 2011**
Total No. of College – 2011	1	-0.173	0.93926	0.87843
PTR – 2011	-0.173	1	-0.004	0.01952
UG + PG+ PhD Enrolment – 2011	0.93926	-0.004	1	0.96159
UG + PG+ PhD Out pass – 2011	0.87843	0.01952	0.96159	1

(Source: Authors' calculation)

Statewide Score and Ranking - 2011:

Sr. No	DMU	Score	Rank
1	Andaman & Nicobar Islands	0.1737	32
2	Andhra Pradesh	1	1
3	Arunachal Pradesh	0.3086	26
4	Assam	0.6274	11
5	Bihar	1	1
6	Chandigarh	1	1
7	Chhattisgarh	0.3699	24
8	Dadra & Nagar Haveli & Daman & Diu	0.101	33
9	Delhi	1	1
10	Goa	0.187	31
11	Gujarat	0.6027	12
12	Haryana	0.5741	13
13	Himachal Pradesh	0.428	21
14	Jammu and Kashmir	0.4106	22
15	Jharkhand	0.4594	20
16	Karnataka	0.7766	9

Sr. No	DMU	Score	Rank
17	Kerala	0.4886	18
18	Madhya Pradesh	0.5422	16
19	Maharashtra	0.9044	7
20	Manipur	0.3359	25
21	Meghalaya	0.2393	28
22	Mizoram	0.2006	30
23	Nagaland	0.2757	27
24	Odisha	0.497	17
25	Puducherry	0.2244	29
26	Punjab	0.5439	15
27	Rajasthan	0.4651	19
28	Sikkim	0.5707	14
29	Tamil Nadu	1	1
30	Tripura	0.3796	23
31	Uttar Pradesh	0.8503	8
32	Uttarakhand	0.7759	10
33	West Bengal	1	1

(Source: Authors' calculation)

Table 2: Showing the Standard Deviation, Correlation Coefficient, Score and Ranks for all states for 2020.

Statistics on Input/Output Data	Total no. of colleges - 2020	PTR - 2020	UG + PG + PhD - Enrolment - 2020	UG + PG + PhD - Out pass - 2020
Max	8114	66	6199528	1288021
Min	9	14	9468	1620
Average	1288.03	28.0882	1105379	247613
SD	1734.98	11.2023	1333669	298646
Correlation	Total no. of colleges - 2020	PTR - 2020	UG + PG + PhD - Enrolment - 2020	UG + PG + PhD - Out pass - 2020
Total no. of colleges – 2020	1	0.02195	0.94467	0.9212
PTR – 2020	0.02195	1	0.21518	0.17481
UG + PG + PhD - Enrolment - 2020	0.94467	0.21518	1	0.98407
UG + PG + PhD - Out pass – 2020	0.9212	0.17481	0.98407	1

(Source: Authors' calculation)

No.	DMU	Score	Rank
1	Andaman and Nicobar Islands	0.197	30
2	Andhra Pradesh	0.6131	11
3	Arunachal Pradesh	0.2231	28
4	Assam	0.5822	14
5	Bihar	1	1
6	Chandigarh	0.6538	10
7	Chhattisgarh	0.4004	21
8	Delhi	1	1
9	Goa	0.1477	32
10	Gujarat	0.5259	17
11	Haryana	0.5883	13
12	Himachal Pradesh	0.3207	23
13	Jammu and Kashmir	0.3702	22
14	Jharkhand	0.5653	15
15	Karnataka	0.7291	8
16	Kerala	0.6825	9
17	Madhya Pradesh	0.7313	7
18	Maharashtra	0.8072	6
19	Manipur	0.2549	26
20	Meghalaya	0.2137	29
21	Mizoram	0.1598	31
22	Nagaland	0.1126	33
23	Odisha	0.5112	20
24	Puducherry	0.2657	25
25	Punjab	0.5225	18
26	Rajasthan	0.5182	19
27	Sikkim	0.2497	27
28	Tamil Nadu	1	1
29	Telangana	0.6035	12
30	The Dadra and Nagar Haveli and Daman and Diu	0.0857	34
31	Tripura	0.2736	24
32	Uttar Pradesh	0.8588	5
33	Uttarakhand	0.5432	16
34	West Bengal	0.9938	4

(Source: Authors' calculation)

References

(2023). PEW Research Centre.

Ahn, T., Charnes, A., & Cooper, W. W. (1988). EFFICIENCY CHARACT ERIZATIONS IN DIFFERENT DEA MODELS. Socio-Econ. Plann. Sci., 22(6), 253-257.

Athanassopoulos, A. D., & Shale, E. (1997). Assessing the Comparative Efficienccy of Higher Education in the UK by the Means of Data Envelopment Analysis. Education Economics, 5(2), 117-134. Retrieved from http://dx.doi.org/10.1080/09645299700000011

Barra, C., & Zotti, R. (2016). Measuring Efficiency in Higher Education: An Empirical Study Using a Bootstrapped Data Envelopment Analysis. Int Adv Econ Res, 22, 11-33. doi:https://doi.org/10.1007/s11294-015-9558-4

Beasley, J. (1990). Comparing University Departments. Omega International Journal of Management Science, 18(2), 171-183.

Beasley, J. E. (1995). Determining Teaching and Research Efficiencies. Journal of the Operational Research Society, 46, 441-452.

Bessent, A. M., & Bessent, E. W. (1980). Determining the Comparative Efficiency of Schools through Data Envelopment Analysis. Educational Administration Quarterly, 16(2), 57-75. doi:https://doi.org/10.1177/0013161X8001600207

Bessent, A., Bessent, W., Elam, J., & Clark, T. (1988). Efficiency Frontier Determination by Constrained Facet Analysis. Operations Research, 36(5), 785-796.

Burney, N. A., Johnes, J., Al-Enezi, M., & Al-Musallam, M. (2013). The Efficiency of Public Schools: The Case of Kuwait. Education Economics, 21(4), 360-379.

Cgarnes, A., & Cooper, W. W. (1980). Auditing and accounting for program efficiency and management efficiency in not-for-profit entities. Accounting, Organizations and Society, 5(1), 87-107. doi:https://doi.org/10.1016/0361-3682(80)90025-2

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.

Charnes, A., & Cooper, W. W. (1982). THE NON-ARCHIMEDEAN CCR RATIO FOR EFFICIENCY ANALYSIS : A REJOINDER TO BOYD AND FARE. CENTER FOR CYBERNETIC STUDIES , 1-6.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 429-444. doi:https://doi.org/10.1016/0377-2217(78)90138-8

Charnes, A., Cooper, W. W., & Rhodes, E. (1981). Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through. Management Science, 27(6), 668-697.

Charnes, A., Cooper, W. W., & Rhodes, E. (1981`). Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through. Management Science, 27(6), 668-697.

Charnes, A., Cooper, W. W., & Thrall, R. M. (1991). A Structure for Classifying and Characterizing Efficiency and Inefficiency in Data Envelopment Analysis. The Journal of Productivity Analysis, 2, 197-237.

Charnes, A., Cooper, W. W., Golany, B., Seiford, L., & Stutz, J. (1985, October-November). Foundations of data envelopment analysis for Pareto-Koopmans efficient empirical production functions. Journal of Econometrics, 30(1-2), 91-107. doi:https://doi.org/10.1016/0304-4076(85)90133-2

Charnes, A., Cooper, W. W., Seiford, L., & Stutz, J. (1982). A multiplicative model for efficiency analysis. Socio-Economic Planning Sciences, 16(5), 223-224.

Charnes, A., Rousseau, J. J., & Semple, J. H. (1996). Sensitivity and Stability of Efficiency Classifications in Data Envelopment Analysis. The Journal of Productivity Analysis,, 7, 5-18.

Conroy, S. J., & Arguea, N. M. (2008). An estimation of technical efficiency for Florida public elementary schools. Economics of Education Review, 27, 655-663.

Cubbin, J., & Tzanidakis, G. (1998). Regression versus data envelopment analysis for efficiency measurement: an application to the England and Wales regulated water industry. Utilities Policy, 7, 75-85

Debreu, G. (1951). The Coefficient of Resource Utilization. The Econometric Society, 19(3), 273-290. doi:https://doi.org/10.2307/1906814

Diamond, A. M., & Medewitz, J. N. (1990). Use of Data Analysis in an Evaluation of the Efficiency of the DEEP Program for Economic Education. The Journal of Economic Education, 21(3), 337-354. Retrieved from http://dx.doi.org/10.1080/00220485.1990.10844680

Diamond, A. M., & Medewitz, J. N. (1990, Summer). Use of Data Envelopment Analysis in an Evaluation of the Efficiency of the DEEP Program for Economic Education. The Journal of Economic Education, 21(3), 337-354.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. Journal of the Royal Statistical Society, 120(3), 253-290.

Firsova, A., & Chernyshova, G. Y. (2019). Mathematical Models for Evaluation of the Higher Education System Functions with DEA Approach. Ser. Math. Mech. Inform., 19(3), 351-362.

Friedman, L., & Sinuary-Stern, Z. (1997). Scaling units via the canonical correlation analysis in the DEA context. European Journal of Operational Research, 100, 629-637.

Gershberg, A., & Schuermann, T. (2001, February). The efficiency-equity trade-off of schooling outcomes: Public education expenditures and welfare in Mexico. Economics of Education Review, 20(1), 27-40. doi:10.1016/S0272-7757(99)00036-9

Gimenez, V. M., & Martínez, J. L. (2006, October). Cost efficiency in the university: A departmental evaluation model. Economics of Education Review, 25(5), 543-553.

Hollingsworth, B., & Parkin, D. (2003, October). Efficiency and productivity change in the English National Health Service: can data envelopment analysis provide a robust and useful measure? J Health Serv Res Policy, 8(4), 230-236. doi:10.1258/135581903322403308

Jesson, D., Mayston , D., & Smith, P. (1987). Performance Assessment in the Education Sector: educational and economic perspectives. Oxford Review of Education, 13(3), 249-266. doi:10.1080/0305498870130302

Johnes, J. (2006). Measuring teaching efficiency in higher education: An application of data envelopment analysis to economics graduates from UK Universities 1993. European Journal of Operational Research, 174, 443-456.

Johnes, J., & YU, L. (2008). Measuring the research performance of Chinese higher education institutions using data envelopment analysis. China Economic Review, 19, 679-696.

Koopman, T. C. (1951). An Analysis of Production as an Efficient Combination of Activities. Cowles Commission for Research in Economics, 13(2), 33-97.

Liu, J. S., Louis, Y. L., Wen-Min, L., & Bruce, J. L. (2013). A survey of DEA applications. Omega, 41(5), 893-902.

Loganathan, M., & Subrahmanya, M. (2023). Efficiency of Entrepreneurial Universities in India: A Data Envelo pment Analysis . J Knowl Econ, 14, 1120-1144. doi:https://doi.org/10.1007/s13132-022-00897

McMillan, M. L., & Datta, D. (1998, Dec.). The Relative Efficiencies of Canadian Universities: A DEA Persp ective. Canadian Public Policy, 24(4), 485-511.

Mizala, A., Romaguera, P., & Farren, D. (2002). "The technical efficiency of schools in Chile,". Applied Economics, Taylor & Francis Journals, 34(12), 1533-1552.

Norman, M., & Stoker, B. (1991). Data Envelopment Analysis: the Assessment of Performance. New York: Wiley.

Ruggiero, J., & Vitaliano, D. F. (1999, July). ASSESSING THE EFFICI ENCY OF PUBLIC SCHOOLS USING DATA ENVELOPMENT ANALYSIS AND FRONTIER REGRESSION. Contemporary Economic Policy, 17(3), 321-331.

Sadlak, J. (1978). Efficiency in higher education — Concepts and problems. Higher Education, 7, 213-220. doi: https://doi.org/10.1007/BF00129419

Sahney, S., & Thakkar, J. (2016). A comparative assessment of the perfor mance of select higher education institutes in India. Quality Assurance in Education, 24(2), 278-302. doi:https://doi.org/10.1108/QAE-02-2015-0006

Salas-Velasco, M. (2020). The technical efficiency performance of the higher education systems based on data envelopment analysis with an illustrati on for the Spanish case . Educ Res Policy Prac, 19, 159–180. doi: https://doi.org/10.1007/s10671-019-09254-5

Schultz, T. (1960). Investment in Human Beings. American Economics Association.

Sengupta, J. K. (1989). Measuring economic efficiency with stochastic input-output data. International Journal of Systems Science, 20(2), 202-213. doi:10.1080/00207728908910120

Sexton, T. R., Silkman, R. H., & Hogan, A. J. (1986). Data envelopment analysis: Critique and extensions. New Directi ons for Program Evaluation, 1986(32), 73-105. doi:https://doi.or g/10.1002/ev.1441

Sinuary-Stern, Z., Mehrez, A., & Barboy, A. (1994). ACADEMIC DEPARTMENTS EFFICIENCY VIA DEA. Compurers Ops Res., 21(5), 543-556

Smith, A. (1776). AN INQUIRY INTO THE NATURE AND CAUSES OF WEALTH OF NATIONS.

Smith, P., & Mayston, D. (1987). Measuring Efficiency in the Public Sector. Omega International Journal of Management Science, 15(3), 181-189.

Tavares, R. S., Angulo-Meza, L., & Sant'Anna, A. P. (2021, December). A proposed multistage evaluation appro ach for Higher Education Institutions based on network Data envelopment analysis: A Brazilian experience. Evaluation and Program Planning.

Tran, T. V., Pham, T. P., Nguyen, M. H., Do, L. T., & Pham, H. H. (2023). Economic efficiency of higher education institutions in Vietnam between 2012 and 2016: a DEA analysis. Journal of Applied Research in Higher Education, 15(1), 199-212.

Veiderpass, A., & McKelvey, M. (2016). Evaluating the performance of higher education institutions in Europe: a nonparametric efficiency analysis of 944 institutions. Applied Economics, 48(16), 1504-1514. doi:https://doi.org/10.1080/00036846.2015.1102844

Wolszczak-Derlacz, J. (2017, Novem ber). An evaluation and explanation of (in)efficiency in higher education institutions in Europe and the U.S. with the application of two-stage semi-parametric DEA. Research Policy, 46(9), 1595-1605.

Worthington, A. C., & Lee, B. L. (2008). Efficiency, technology and productivity change in Australian universities, 1998–2003. Economics of Education Review, 27(3), 285-298.